THE

JOURNAL

OF

THE ASIATIC SOCIETY

OF

BENGAL.

VOL. II.

THE JOURNAL OF THE ASIATIC SOCIETY OF BENGAL.

EDITED BY

JAMES PRINSEP, F. R. S.

SECRETARY OF THE ASIATIC SOCIETY.

VOL. II.

JANUARY TO DECEMBER,

1833.

"It wiil flourish, if naturalists, chemists, antiquaries, philologers, and men of science, in different parts of *Asia*, will commit their observations to writing, and send them to the Asiatic Society at Calcutta; it will languish, if such communications shall be long intermitted; and it will die away, if they shall entirely cease."

SIR WM. JONES.

Calcutta:

PRINTED AT THE BAPTIST MISSION PRESS, CIRCULAR ROAD

SOLD BY MESSRS. THACKER AND CO. ST. ANDREW'S LIBRARY.

1833.

PREFACE.

On completion of this second volume of the Journal of the Asiatic Society, the Editor feels it to be due to his subscribers, as well as to himself, to lay before them as briefly as possible, the results of the arrangements which he contemplated carrying into effect at the conclusion of the last volume;—more especially as a somewhat erroneous estimate of the cost and circulation of the Journal found admission into a late notice of the Indian Periodical Press, drawn up by the Editor of one of the morning papers. The Journal is not published, as there stated, by the Asiatic Society, but solely at the cost and responsibility of the Secretary, who was Editor of it before he enjoyed the honour of an election to that office. Since there never has been the least view to profit, either in the Gleanings or in the present work, there can be no object whatever in concealing any information respecting its publication; and it may be useful hereafter to find on record a note of the expences of printing, and the difficulties against which a Journal exclusively scientific has had to contend, as well as the advantages which it has enjoyed, in India at the present time. The following particulars have therefore been extracted from the accounts of the two years now terminated.

The amount of subscriptions to the Journal at one rupee per number, including two extra numbers, in 1832, was .... Rs.		5148 8
From this, deducting 20 per cent. commission paid to Messrs. Thacker and Co. for circulating it, ...		1028 11
There remained net subscriptions available, Rs.		4114 13
The Baptist Mission Press charged for printing and stitching 500 copies,	Rs. 3742 10	
And the 15 plates cost with printing,	416 5	
Total		4178 5

The result of the first year exhibits a sufficient accordance between outlay and return. Of the amount subscribed however, only Rs. 3786 13 have been collected up to the present time, so that in fact there was a deficit of Rs. 392 2.

The alterations which the Editor proposed and completed for the second year were:—

1. The saving of nearly half of the commission paid for the mere circulation of the work (without responsibility), by undertaking that duty with the aid of his establishment as Secretary of the Asiatic Society;

2. As a return for this favor, he proposed circulating the Journal gratis to such of the paying members as should express a desire to take it in.

The effect of this scheme has been as follows:

Fifty members of the Society have availed themselves of the privilege, which has made a deduction to the same amount from the monthly receipts. The number of copies circulated, including those sent to subscribers and societies in Europe, is about 450.

The number of paying subscribers on the list, is 320, which at 1 R. per month, (including one extra number of Buchanan,) would give Rs. 4480.

The expenses of printing 500 copies, of 670 pages, at 4-5 per page, may be stated at	Rs. 2,890	
144 pages of Buchanan, at 4-8 per page,........	648	
Covers, table work, &c. charged extra, ...	250	
40 pages of Appendix, at 5 Rs..................	200	
28 plates (18 lithographs, 10 engravings*), ...	480	
Establishment for circulation, ...	600	
	——	5,068

Leaving a loss on the year of Rs. 588, or nearly as much as the subscriptions of the members exempted from paying.

But it must be mentioned, and mentioned with a degree of disappointment which is almost disheartening, that of the flattering list of sub-

* For these the cost of printing and paper only is charged.

scribers above given, 70 have not paid any part of the year's subscription, and as many more are still in arrears; so that a balance of Rs. 1321-8 still remains to be collected. The actual state of the concern is therefore by no means so favorable as could be wished, for it leaves the Editor out of pocket upwards of 2000 Rs. as the reward of his labour for two years! B əq ʇnwill not for a moment suppose that the balances outstanding are not recoverable: on the contrary the principal difficulty lies in the distance, and the supposed want of a mode of remittance.—Many subscribers are not aware, that letters containing hoondees for the amount may be transmitted *post free* to the Editor.

It will be remembered, that the Bengal Government were pleased to bestow the privilege of free postage on the GLEANINGS and on the JOURNAL, on condition of the publication of the late Dr. Buchanan's Statistical Reports. Under the impression (justly formed) of a corresponding increase of circulation, consequent upon this liberal boon, it was resolved not to incorporate these records in detached notices in the JOURNAL, nor to diminish from its original matter*, but to publish them as a separate work; and one volume has accordingly been completed,

containing 356 pages, which at 4-8 per page have cost Rs.	1,602
And a reprint of the first 108 pages, which became necessary on the subsequent extension of the edition from 300 to 500 copies,	216
Total, Rs.	1818

This expence has been incurred therefore on account of Government, in return for the postage saved, not to the work, but to the subscribers of the JOURNAL. On the completion of the first volume of BUCHANAN, a second extra volume of an official nature on the Monetary System was commenced, of which 50 pages have been printed with 3 plates, being in fact an expence of more than 300 rupees not included in the above estimate. The Government meantime placed the remaining volumes of Buchanan in the Editor's hands, with an intimation of its "desire that the printing of these records should be continued." It was therefore with no small feeling of mortification that

* Originally 32 pages only were given in each number, latterly 64.

the Editor perused the following letter, announcing that the privilege of free postage should cease from June next, especially after having been honored, on an explanation of the nature of the work, with an extension of the same privilege to the Madras presidency, in addition to that formerly bestowed by the Governors of Bombay and Ceylon.

To JAMES PRINSEP, Esq.

Genl. Dept. Editor of the Journal of the Asiatic Society,

Sir,

I am directed to inform you, that the Governor General in Council has resolved, that after six months the exemption from postage, which is now enjoyed by the Journal of the Asiatic Society, shall be discontinued.

I have the honor to be,
Sir,
Your most obedient servant,
G. A. BUSHBY,
Offg. Sec. to Govt.

Council Chamber,
2nd Dec. 1833.

It may reasonably be feared that many subscribers at distant stations may be unable to continue their support to the work, when its cost shall be enhanced by postage; but (should it be impossible, on a proper and respectful representation of the circumstances, to avert the imposition of postage) every means will be taken of lessening the burthen by sending the monthly numbers by the bangy instead of the regular dâk.

On the contents of a volume which has already been perused by nearly all to whom it circulates, it would have been obviously needless to make any remark, were it not desirable to prove that the favors hitherto conferred upon the work by the Government of the country had not been altogether misapplied.

Independently of the volume of Dinajpur Statistics, which forms a model for the use of public officers engaged in collecting similar information, the Gleanings and the Journal have been the means of bringing to notice many of the mineral resources of our vast Indian Empire, and of leading to fresh discoveries by the announcement of what had already been found: coal may be adduced as an example,—of which twenty or more different localities have been brought to our knowledge through its pages, where only two were before known. Of the native mineral productions, iron, copper, gold, &c.:—Of the native arts and manufactures, salt, nitre, turpentine, dyes, mills, &c. numerous original ac-

counts have been inserted : catalogues of woods, medicinal plants and drugs : experiments on materials, wood, iron, cement ;—Statistical reports ;—descriptions of newly explored countries and people :—in fact, it would be difficult to open a number of the JOURNAL without finding some information which must possess value in the eyes of a government. Contributions of a more exclusively scientific nature have, in the mean time, continued to multiply, and the objects pointed out as desiderata at home in the geography, meteorology, geology, and natural history of this country, are in the course of rapid and systematic elucidation. So numerous for instance have been the registers of the weather offered for publication, that space could only be found for abstracts of many. There has hardly been time for the collection of materials regarding the tides of the Indian coasts, suggested in the Rev. Professor WHEWELL's circular, (inserted in page 151,) but the attention of those who have opportunities of eliciting the information required, is again solicited to this object.

As a proof of the benefit conferred on science by the free and extensive circulation of a periodical devoted to such objects, the Editor feels pride in alluding to the ardour which his plates of ancient coins have inspired in many active collectors, and above all to the reward bestowed ou himself by the munificence of General VENTURA, the most successful pursuer of antiquarian research in the Panjáb, who has presented to him all the coins and relics discovered on opening the celebrated Tope of Manikyala. They are now on their way to Calcutta.

That extracts and analyses of European science have not been more frequent must be attributed once more to want of space and want of leisure. The Editor would recommend all who seek for knowledge of the progress of science in Europe to procure a copy of the Reports of the British Association for 1832, in which they will find every branch discussed by the philosopher best able to give it illustration. To attempt to shorten those admirable essays would be mutilation rather than abridgment; yet unfortunately most of them are too long for the pages of a monthly journal.

On the subject of orthography of native words, the Editor is driven to make one concession, for which he fears the learned Societies at home

will denounce him as an apostate to the system of their leader. Every communication, with hardly any exception, which comes for publication, adopts the Gilchristian mode of spelling, or that modification of it which has been *ordered* to be used in all Government records, surveys, &c. An attempt has been made hitherto to conform the whole to Sir William Jones' method, but necessarily there have been continual omissions, and the contributors in most cases express themselves but ill pleased to see their words transformed into shapes but ill accordant with ordinary *English* pronunciation. The Editor has therefore resolved to adopt the middle course followed in Hamilton's Hindustan, namely, to print all Indian names and words in the ordinary roman type as they are usually written and pronounced, and to place in italics all such native terms and proper names, as are corrected, and spelt according to the classical standard of Sir William Jones: in many cases the latter may be inserted in brackets after the ordinary word.

Where contributors have occasion to illustrate their papers by plates, it will be a great convenience to the Editor to have the original drawings prepared of the same dimensions as the printed page of letter press, to save the trouble and expence of reducing them.

The Editor will not allude in this place to the severe loss he has sustained in the death of some of the most able and constant supporters of his work, and the departure to Europe of others in the course of the past year; since he hopes that a more worthy channel will be found for the record of their meritorious labours for the cause of Science in India, in the Proceedings of the Asiatic Society, to which their names belong, and in which their reputation must ever be cherished with fond remembrance.

1*st January*, 1834.

LIST OF SUBSCRIBERS, 1833.

[The names marked with an asterisk have availed themselves of the privilege of taking the Journal gratis, as members of the Asiatic Society : *d*, after a name, denotes *deceased* or *discontinued.*]

The Honorable the Court of Directors, (By the Secretary to Government, General Department,) one copy.

*The Right Honorable Lord W. C. Bentinck, Governor General, &c. one copy.

*The Honorable Sir C. T. Metcalfe, Bart. Member of Council, one copy.

*The Honorable Sir E. Ryan, Knt. Chief Justice, one copy.

*The Right Rev. Lord Bishop of Calcutta, one copy.

The Venerable Archdeacon Corrie, one copy.

Subscribers for twelve copies.

The Physical Class, Asiatic Society.

Subscribers for four copies.

Hyderabad Book Society.

Subscribers for two copies.

P. Andrew, Esq. Calcutta.
Major A. Irvine, Delhi.
J. J. Malvery, Esq. Bombay.

Subscribers for one copy.

Abercrombie, Lieut. W. Hazareebagh.
Agra Book Club.
*Anburey, Col. Sir Thos. Calcutta.
Artillery Book Club, Dum-Dum.
Atherton, H. Esq. Futtygurh.
*Avdall, J. Esq. Calcutta.

Baikie, Dr. Ootacamund.
Baker, Capt. H. C. England.
Baker, Lieut. W. E. Seharanpur.
Ballard, Geo. Esq. Calcutta.
Barlow, J. H. Esq. Bagundee.
Barrett, M. Esq. Calcutta.
Barrow, H. Esq. Ditto.
Batten, J. H. Esq.
Batten, G. M. Esq. Calcutta.
Beatson, Lieut.-Col. W. S. Ditto.
Beckett, J. O. Esq. Coel.
Bedford, Capt. J. Allahabad.
Bell, Dr. H. P. Calcutta.
Bengal Club, Ditto.
Benson, W. H. Esq. England.
*Benson, Major R. Ditto.
Betts, C. Esq.
Bird, W. W. Esq. Calcutta.
Blair, Major J. Barelly.
Blake, Capt. B. Cuttack.
Blake, H. C. Esq. Dhobah, near Culnah.
Blechynden, A. H. Esq. Calcutta.
Boileau, Lieut. J. T. Agra.
Boileau, Lieut. A. H. E. Ditto.
Bombay Asiatic Society.
Boulderson, H. S. Esq. Seharanpur.
Boulderson, S. M. Esq. Azimgurh.
Boutrons, T. Esq. Purneah.
Bramley, Dr. M. J. Calcutta.
Brander, Dr. J. M. Cuttack.
Bridgman, J. H. Esq. Goruckpore.
Bridgman, Lieut. P. Agra.
*Briggs, Col. J. Nagpore.
Brittridge, Capt. R. B. Barelly.
Brooke, W. A. Esq. *d.*
Brownlow, C. Esq. Calcutta.
Browne, Capt. W. Seharanpur.
Brown, Lt. E. J. Engineers, Allahabad.
Browne, G. F. Esq. Jounpore.
Bruce, W. Esq. Calcutta.
*Bryant, Col. Sir J. Head Quarters.
*Burke, W. A. Esq. Ditto.
*Burnes, Lieut. A. England.
*Burney, Major H. Ava.
Burt, Lieut. T. S. Allahabad.
Butter, Dr. D. Ghazipur.
Bushby, G. A. Esq. Calcutta.
Byrn, W. Esq. Ditto.

Calcutta Periodical Book Society.
*Calder, J. Esq. Calcutta.
Campbell, Dr. D. Mirzapore.
Campbell, D. A. Esq. Nipal.
Campbell, J. Esq. Cawnpore.
Campbell, Dr. Arch. Moulmayne.
Carey, Rev. Dr. W. Serampore.
Carr, W. Esq. Calcutta.
Carte, Dr. W. E. Hansi.
Casanova, Dr. J. Calcutta.
*Cautley, Lieut. P. T. Seharanpur.
Chambers, R. G. Esq. Surat.
Cheek, Dr. G. N. Bancoorah.
Clarke, Dr. J. Calcutta.
Coignard, E. Esq. Junghipur.
Cole, R. Esq. Madras.

*Colvin, Major J. Delhi.
Colvin, A. Esq. *d.*
*Colvin, J. R. Esq. Calcutta.
Conolly, Lieut. E. B. Cawnpore.
Conoylaul Tagore, Baboo, Calcutta.
Coombs, Lieut.-Col. *d.*
Cope, Gunner, Meerut.
Cracroft, W. Esq. Dacca.
Crawfurd, W. Esq. Seharanpur.
Crommelin, Capt. A. Barrackpur.
*Csoma de Körös, Calcutta.
Cullen, Col. W. Madras.
Cunningham, Lieut. J. D. Rajmahal.
Cunningham, Lieut. A. Berhampur.
Curtis, J. Esq. Calcutta.

Dalby, Lieut. G. M. Calcutta.
De Courcy, R. Esq. Kishnaghur.
Delhi Book Society.
Dennis, Capt. G. G. Meerut.
Dickens, T. Esq. *d.*
Dixon, Capt. C. G. Ajmere.
Dobbs, A. Esq. Calcutta.
Dorin, J. A. Esq. Ditto.
Douglas, H. Esq. Patna.
Drummond, Capt. J. G. Allahabad.
Dubois, Col. A. Lucknow.
Duff, Rev. A. Calcutta.
Dunlop, Lieut-Col. W. Cawnpore.
Durand, Lieut. H. M. Meerut.

Eckford, Dr. J. Nussirabad.
Edgeworth, M. P. Esq. Umbala.
Editor Bombay Liter. Gaz.
Editor Calcutta Courier.
Editor Calcutta Liter. Gaz.
Editor Colombo Journal, Ceylon.
*Egerton, C. C. Esq. Calcutta.
Eisdale, D. A. Esq. Poona.
Ellerton, J. F. Esq. *d.*
Elliot, J. B. Esq. Patna.
Elliot, W. B. Esq. Bauleah.
Erskine, D. Esq. Elambazar.
Evans, Dr. Geo. Calcutta.
Everest, Rev. R. Delhi.
*Ewer, W. Esq. Allahabad.

Fagan, Lieut. G. H. Cawnpore.
Fagan, Brig. C. S., C. B., Neemuch.
Falconer, Dr. H. Seharanpur.
Fane, W. Esq. Allahabad.
Ferguson, W. F. Calcutta.
Fiddes, Col. T. Muttra.
Fisher, Lieut. T. Kachar.
Fitzgerald, Capt. W. R. Calcutta.
Forbes, Capt. W. N. Ditto.
Fraser, H. Esq. (Senr.) Delhi.
Fraser, A. Esq. Ditto.
Fraser, C. S. Esq. Saugor.
Frith, Lieut.-Col. W. H. L. Dum Dum.

Garden, Dr. A. Calcutta.
Gardner, Col. W. L. Lucknow.
Gerard, Capt. A. Hansi.
Gerard, Capt. P. Subathu.
Gerard, Dr. J. Ditto.
Gilchrist, Dr. W. Vizianagaram.

*Gordon, G. J. Esq. Calcutta.
Gorton, W. Esq. Benares.
Governor (His Exc. the) of Ceylon.
Gowan, Capt. E. P. Calcutta.
Grœme, H. S. Esq. *d.*
Graham, J. Esq. Calcutta.
Grant, J. W. Esq. Hurripaul.
Grant, Lieut. C. E. *d.*
Grant, Capt. W. Benares.
Grant, J. Esq. Calcutta.
Grey, E. Esq. Calcutta.
Greenlaw, C. B. Esq. Ditto.
Gubbins, C. Esq. Delhi.

Hall, Lieut. J. H. Kalladghee.
Hamilton, H. C. Esq. Bhagulpur.
Harding, Ben. Esq. Calcutta.
*Hare, D. Esq. Ditto.
Harris, F. Esq. Ditto.
Hart, Dr. T. B. Saugor.
Henderson, Dr. J. Agra.
*Herbert, Capt. J. D. *d.*
Hodges, Lieut. A. Sunderbunds.
Hodgson, B. H. Esq. Nipal.
Hodgson, B. Esq. Kishnaghur.
Holcroft, V. Esq. *d.*
Homfray, J. Esq. Care of Messrs. Jessop and Co.
Horse Brigade, Artillery, Meerut.
Howrah Dock Company, Calcutta.
Howstoun, R. Esq. Backergunge.
Huddleston, Lieut. H. Goruckpur.
Hunter, R. Esq. Púrí.
Hunter, J. Esq. *d.*
Hutchinson, Major G. Calcutta.
Hutchinson, Capt. F. Bombay.
Hutton, Lieut. T. Neemuch.

Inglis, Esq. China.
India Gaz. Press, Calcutta.
Inverarity, Lieut. J. Engineers, Madras.

Jackson, Dr. A. R. Calcutta.
Jeffreys, Dr. J. Ditto.
Jenkins, Capt. F. Ditto.
Jervis, Capt. Thos. Ootacamund.
Jones, Capt. N. Cawnpore.
Jopp, Capt. J. Poona.
Kali Kissen, Moharaja, Bahadoor.
Kean, Dr. Arch. Murshedabad.
Kennedy, Lieut. T. Bombay. *d.*
Kerr, A. J. Esq. Malacca.
King, Dr. Geo. Patna.
Kassipersaud Ghosa, Baboo, Calcutta.
Kyd, J. Esq. Ditto.
Laidly, J. W. Esq. Beerbhoom.
Lamb, G. Esq. Dacca.
Lambert, W. Esq. Allahabad.
Langstaff, Dr. J. Calcutta.
Laughton, Dr. R. *d.*
Law, J. S. Esq. Surat.
Lindsey, Dr. A. K. Chunar.
Lindsay, Col. A. Dum Dum.
Lloyd, Capt. Rich. Calcutta.
Lockett, Col. A. Ajmere.
Logan, Geo. Esq. Seharanpur.
Login, J. S. Esq. Hyderabad.

Louis, J. Esq. Bouleah. *d.*
Louis, T. Esq. Moradabad.
Lowther, W. Esq. *d.*
Lowther, R. Esq. Allahabad.
Lushington, G. T. Esq. Bhurtpoor.
Macdonald, Lieut. R. Saugor.
Macdowal, W. Esq. Rungpur.
Macfarlan, D. Esq. Calcutta.
Macgregor, D. W. L. Loodianah.
MacCheyne, W. O. H. Esq. Nusseerabad.
Mackenzie, Lieut. J. 8th L. I. Cawnpore.
Maclennan, Dr. J. Bombay.
Macleod, D. A. Esq. Assam. *d.*
Macleod, Col. D. Murshedabad.
*Macnaghten, W. H. Esq. Calcutta.
Macpherson, Lieut. S. Hyderabad.
MacRitchie, J. Esq. Bancurah.
Madras Club.
Mainwaring, T. Esq. *d.*
Malcolmson, Dr. I. N. Nagpore.
Mannuk, M. M. Esq. Calcutta.
Manson, Capt. J. Bittour.
Marshall, Capt. G. T. Calcutta.
Marshman, Rev. Dr. J. Serampore.
Martin, Lieut. R. Delhi.
*Martin, J. R. Esq. Calcutta.
Martin, C. R Esq. Ditto.
Martin, W. B. Esq. Indore.
Master, W. Esq. Calcutta.
* Mendez, F. Esq. Ditto.
Mess Library, 11th Light Dragoons.
Miles, Lt. R. H. Futtyghur.
*Mill, Rev. Principal Dr. W. H.
Milner, Captain E. T. Almorah.
Military Board, Calcutta.
Military Library Society, Mhow.
Montgomery, Dr. W. Penang.
Montrion, Lt. C. Calcutta.
Moore, Capt. J. A. Hyderabad.
Morgan, R. W. Esq. Tirhoot.
Morley, C. Esq. Calcutta.
Morris, J. C. Esq. for Mad. Lib. Socy. Madras.
Morris, J. C. Esq. Arrah.
Morse, Major A. Bombay.
Mouatt, Lt. James A. Kurnal.
Mouatt, Dr. J. A. Pres. Bangalore B. Socy. Bangalore.
Muller, A. Esq. Calcutta.
Murray, Capt. H. R. Noacolly.
Muzzufferpore Book Club, Tirhoot.

Napier, Lieut. R. J. Seharanpur.
Nash, Dr. D. W. Hyderabad.
Nicholson, Capt. M. Jabalpur.
'Nicholson, S. Esq. Calcutta.
Nisbet, W. Esq. *d.*
Noton, B. Esq. England.
Nussirabad Book Society.

Officers, 73rd Regt. N. I. Benares.
——— H. M. 16th, Chinsurah.
——— 40th Regt. N. I. Allyghur.
——— 12th Regt. N. I. Lucknow.
Oliver, Major T. Nussirabad.
Oliver, Hon'ble W. Madras.
Ommaney, Lieut. E. L. Dacca.
Ommaney, M. C. Esq. Saugor.
Ostell, T. Esq. Calcutta.

Pakenham, T. Esq. Calcutta.
Parental Ac. Institution, Ditto.
Parker, H. M. Esq. Ditto.
Patrick, W. Esq. Fort Gloster.
Patton, Capt. J. W. *d.*
*Pearson, Dr. J. T. Calcutta.
*Pemberton, Capt. R. B. on Survey.
Persidh Narain Sing, Baboo, Benares.
Piddington, H. Esq. Chonadinga Factory.
Pigg, T. Esq. Calcutta.
Playfair, Dr. Geo. Meerut.
Plumb, J. R. Esq. Calcutta.
Poole, Col. E. Ditto.
Pratt, Geo. Esq. Purneah.
Presgrave, Major D. Saugor.
*Prinsep, H. T. Esq. Calcutta.
Prinsep, Miss, England.
*Prinsep, C. R. Esq. Ditto.
*Procter, Rev. T. Ditto.
Proprietors of the John Bull, Ditto.
Pyle, J. C. Esq. Futtyghur.

*Radhacaunt Deb, Baboo, Calcutta.
*Ramcomul Sen, Baboo, Ditto.
Ramsay, Capt. W. H. Head Quarters.
Ranken, Dr. J. Delhi.
Rattray, R. H. Esq.
*Ravenshaw, E. C. Esq.
Renny, Lieut. T. Agra.
Renney, D. C. Muttra.
Rhodes, D. W. Sylhet.
*Richy, Monsr. A. L. Calcutta.
Roberts, Major A. Ditto.
Robertson, T. C. Esq. Sylhet.
*Robison, C. K. Esq. Calcutta.
Rogers, Esq. Ditto.
Ross, A. Esq. Ditto.
*Ross, D. Esq. Ditto.
Ross, Capt. D. Gwalior.
Routh, W de H. Esq. Boolundshuhr.
Row, Dr. J. Bandah.
Royle, Dr. J. England.
Ruspini, Rev. W. Dinapur.

*Sage, Capt. W. Dinapur.
Sale, Lieut. T. H. Delhi.
Sanders, Capt. E. Cawnpur.
Sandy, T. E. Esq. Arrah.
Sandys, Rev. T. Calcutta.
Satchwell, Capt. J. Dinapur.
Saunders, Geo. Esq. Calcutta.
Saunders, J. O B. Esq. Coel.
Scott, D. Esq. Burdwan.
Seaton, Lieut. T. Jamalpur.
Sevestre, Robt. Esq. Calcutta.
Shaw, T. A. Esq. Chittagong.
Shore, Hon'ble F. J. Futtyghur.
Shortreed, Lieut. R. Poona.
Siddons, Lieut. H. Berhampore.
Simmonds, Capt. J. H. *d.*
Sleeman, Capt. W. H. Jabalpur.
Sloane, W. Esq. Tirhoot.
Smith, T. P. Esq. Baitool.

Smith, Samuel and Co. Calcutta.
Smith, Capt. E. Ditto.
Smith, Lieut. J. T. Musulipatam.
Smyth, Capt. W. H. Calcutta.
Smyttan, Dr. Geo. Bombay.
Society Nat. His. Mauritius.
Southby, Capt. F. S. Calcutta.
Sparks, Capt. J. P. Ghazipur.
Speed, D. W. H. Esq. Calcutta.
Spiers, A. Esq. Allahabad.
Spilsbury, Dr. G. G. Jabalpur.
Spry, Dr. H. H. Saugor.
Stacy, Lieut.-Col. L. R. Nussirabad.
Stacy, S. P. Esq. Calcutta.
Stainforth, F. Esq. Goruckpur.
Stephenson, J. Esq. Patna.
Stevenson, Dr. W. Jun. Calcutta.
*Stirling, E. Esq. Allyghur.
Strokes, Dr. J. Hamirpur.
*Strong, F. P. Esq. Calcutta.
Sutherland, Capt. E. Calcutta.
Sutherland, Hon'ble J. Bombay.
Sweetenham, H. Esq. Futtyghur.
Swiney, Dr. J. Kurnal.
*Swinton, G. Esq. England.
Sylhet Book Club.

Tanner, Capt. W. F. H. Monghyr.
Taylor, T. G. Esq. H. C. Astronomer, Madras.
Tayler, J. Esq. Dacca.
Telfair, C. Esq. Mauritius *d.*
Terraneau, Capt. W. H. Sylhet.
Thomas, C. Esq. Singapore.
Thomas, Dr. W. Barrackpur.
Thomas, E. F. Esq. Kemaon.
*Thomason, J. Esq. Azimgurh.
Thompson, Capt. G. Hazareebagh.
Thompson, Capt. J. Calcutta.
Thoresby, Capt. C. Berhampur.
Tickell, Col. R. Barrackpoor.
Tierney, M. J. Esq. *d.*
Trade Association, Calcutta.
Trail, G. W. Esq. Kemaon.
Tremenherlt, Lieut. G. B. Delhi.
*Trevelyan, C. E. Esq. Calcutta.
*Trotter, R. Esq. Gyah.
*Troyer, Capt. A. Calcutta.
Turner, T. J. Esq. Seharanpur.
Twemlow, Capt. G. Arungabad.
*Twining, W. Esq. Calcutta.
*Tytler, J. Esq. Ditto.

Udny, C. G. Esq. Calcutta.

Vicary, Lieut. N. Meerut.

*Wade, Capt. C. M. Loodianah.
Walters, H. Esq. Chittagong.
*Wallich, N. Esq. Calcutta.
Warner, Capt. J. H. Bauleah.
*Watson, Col. T. C. Dacca.
Watt, A. Esq. Singapur.
Waugh, Lieut. A. H. Agra.
Webb, L. W. Esq. Surat.
Wells, F. O. Esq Monghyr.
Western, Lieut. J. R. Midnapur.
White, Rev. E. Cawnpore.
Wilcox, Capt. R. Gt. Trig. Surv.
Wilkinson, W. Esq. Pooree.
Wilkinson, J. E. Esq. *d.*
Winfield, Capt. J. S. Bhopal.
*Wilson, H. H. Esq. England.
Wise, Dr. T. A. Hoogly.
Wise, J. P. Esq. Dacca.
*Withers, Rev. G. N. Calcutta.
Wood, Dr. Arthur, Simlah.
Woodburn, Dr. D. Shirghati.
Woollaston, M. W. Esq. Calcutta.

Zeigler, L. Esq. Setapur.

CONTENTS.

No. 13.—JANUARY.

No. 14.—FEBRUARY.

JOURNAL

OF

THE ASIATIC SOCIETY.

No. 22.—*October*, 1833.

I.—*A visit to the Gold Mine at Battang Moring, and Summit of Mount Ophir, or "Gunong Ledang," in the Malay Peninsula. By Lieut.* J. T. Newbold, 23*rd Regt. Mad. L. Inf.*

On the 20th April, I arrived at *Assahan* from *Malacca* on route to Mount Ophir. *Assahan* lies about 31 miles E. N. E. from *Malacca*, and is our most advanced outpost towards the frontier of the independent state of *Muar*. The stockade is situated on the summit of a knoll partially cleared of wood and crowned by cocoanut trees; it consists of a defence of upright piles driven deep into the ground, and is about sixteen yards square, with a low banquette running round; enclosed by this is a small unfinished caserne capable of accommodating thirty men, construeted of *Atap*. The knoll terminates on the north-east and west in a swampy *sawah*, and is approached by a footpath traversing some rough ground from the south; through the eastern part of the *sawah* runs the *Assahan* rivulet, and beyond this is a stretch of forest amid which lies enshrouded Ophir's gigantic foot. *Assahan*, owing to the exactions and tyrannies practised by the petty *Malayan* chiefs around, has been almost deserted by the native population; who are now, however, re-assured by the presence of our troops, slowly returning to their ravaged homes.

At a quarter to one P. M. Lieut. Hawkes and myself left *Assahan*, with a *posse comitatus* consisting of a naique, six sepoys, and six convicts; Amas Karo, the *Panghulu* of *Sunjiedua*, the *Imam* of *Bokko*, Daniel Peters the Portugueze interpreter, Nasep an Abyssinian, and a guide named *Haji*, with ten Malays provided with "*parangs*" to clear a path through the thick underwood and numerous ratans and creepers with which a Malay forest abounds. After travelling along

a footpath through a dense jungle for an hour or so, we crossed the frontier into the *Muar* territory. The boundary mark, as pointed out by the Malays, is a large *Bankon* tree growing close to the path on the right hand. After crossing the *Schong* and *Gummi* streams we arrived at the latter place at a quarter-past 3, P. M.

Gummi is, or rather was, a small village situated close to the foot of Mount Ophir: it contained about 20 houses, almost all of which have been forsaken by their inhabitants, owing to causes before-mentioned. It does not appear to have ever benefited by excess of cultivation, but probably owed its former population to the proximity of the gold mines, which merit a brief description.

About sixty yards from the deserted hut which constituted our "*Serai*," nearer the mountain, is a house almost concealed by the sloping ground on which it stands, inhabited by six or seven Chinese miners, and immediately in front of it is a gold mine. This place is called *Battang Moring*. The mine is nearly exhausted; it is situated on the flat marshy ground at the foot of the slope on which the Chinese house stands; in length it measures about ten yards, by four in breadth; and six or seven feet in depth.

It is filled with muddy water, which is drained off by a simple bamboo hydraulic apparatus somewhat resembling the Indian *Pukotah.* The miners descend for the purpose of digging out the metallic earth, by means of rude ladders formed of the notched trunks of trees; a Chinese, who had embraced Muhammedanism, went through the process, which is extremely simple: having dug out a quantity of the earth, which consists of coarse sand, greyish clay and white pebbles, among which crystals of quartz are found, and greenish stones, he placed it in a shallow funnel-shaped vessel of wood, and carried it to a stream of water, conducted by two narrow channels close to the mine.

The water falling from a height of about a foot washes away the lighter earthy particles and clay, assisted by the rotatory motion of the miner's hand. This done, he carefully picks out the stones and other refuse too large for the water to carry off, whilst the gold dust, in minute portions, sinks to the narrow bottom of the vessel, from which it is extracted, carefully washed, and laid by to be made up into small bags each containing one *bunkal,* ($1\frac{1}{2}$ oz. tr.)

The gold of Ophir, though small in quantity, is as fine as that of *Pahang* in quality, being estimated at ninety touch. A gentleman of the Madras Medical Establishment, to whom I showed the crystals and

earth, is of opinion that the latter is the debris of the granite forming the summit; the white masses appearing to be felspar in a decomposed state.: the crystals are quartz, and the small grains in the earth also quartz. The gold found in it he supposes to be washed down from the mountain as the rock became disintegrated.

The Chinese showed me a specimen of a stratum of clay of a greenish grey colour, beneath which gold is never found; this is the case with the present mine, which they intend quitting to open another a few paces distant.

The Chinese affirm that one mine does not produce monthly more than one *tael* of gold. This is probably designedly underrated. A tribute is exacted from each individual of one dollar monthly for the privilege of mining here, by the petty Malay chiefs, Inches Ahad and Mahmed.

They levy it in person every two months. These two chiefs are nominally under the *Tamangong* of *Muar,* (whose maternal uncles they are,) but in reality are little better than banditti.

I give the following on the authority of the head Chinese miner at *Moung,* as the names of the places around Mount Ophir (for the gold is always procured at the foot), where mines have been established :—

Battang Moung, Kedanon, Rejang, Kaddam, Tanong, Paeedalum, Berinjin, Terring, Kayo Arro, Kamoyan, Jongi, Deddam, Poggi Baru, Chindagon, Ayer Kuning, and *Ayer Chamhi.*

He also informed me that, formerly, nearly 1000 Chinese worked in these mines; but that of late, owing to the unsettled state of the country, they had nearly been deserted. The Chinese, who still work at the mines in spite of the oppression they suffer, depend on *Malacca* for their supplies, for which they occasionally dispatch two or three of their number, who take down with them the small portion of gold dust they have been able to scrape together. The wild and deserted state of the country, and the extent of forest to be traversed between the foot of the mountain and *Malacca,* afford opportunities, not unfrequently taken advantage of, by the marauders that infest the frontier, for the sake of the pittance of rice and salt fish, and a few grains of gold dust. Murder is almost invariably added to robbery. Shortly after my visit, two of these Chinese going up to the mines were found murdered, in the heart of the *Rheim* forest on the road; one with his head nearly severed from the body; the corpse of the other lay about 300 paces from that of his comrade: he appears to have sought safety

in a vain flight ; his left arm was cut through at the elbow, and body horribly mangled.

We had a fine view of the mountain from *Gummi,* as the clouds which had hitherto wrapt its triple peak in grey obscurity, now rolled off in majestic wreaths, revealing to us Ophir's picturesque proportions.

We started from *Gummi* at 9 A. M. on foot : the Malays went on in advance clearing the path through the low thicket, through which our path now lay, to the banks of the *Jerram* river, along which we waded for some distance ; near this we crossed the track of a rhinoceros. About a mile and a quarter from the river stood the deserted house of a Malay, the last trace of human habitation ; this place the Malays call *Rullowe,* which I believe signifies a place where metal is melted, or the smoke which is produced by fusion ; from this it may not be unreasonable to infer that a mine formerly existed in this vicinity.

A little in advance of *Rullowe* the ascent of Mount *Tando* commences ; this is the longest but most gradual of the three acclivities which constitute the ascent. Having descended this and scaled part of *Gunong Perudap,* we arrived at a steep bank of rock, called *Padang Battu* or *Plain of stone.* On the right of *Padang Battu* the rush of the river *Jerram* down the mountain side was distinctly audible. The surface of the rock is intersected by numerous creepers, which formed a sort of rope ladder we were glad to avail ourselves of. Here we rested a short time, enjoying the extensive prospect this elevated situation afforded. Leaving *Padang Battu* far below, stands on *Peradap's* summit a bluff rock named *Battu Serambi,* which signifies "*the rock of the porch.*"

The rock was first mistaken for the peak itself, but on arriving at the bushy platform that crowns *Serambi's* mossy head, Ophir still stood before us, nearer, but steeper and as lofty apparently as ever. A short descent brought us to the bottom of the third and last ascent, viz. *Gunong Ledang.* The trees here are of a stunted and venerable appearance, being for the most part covered with moss and lichens, a thin carpet of which barely conceals the primitive rock beneath : we had lost sight here of animals larger than the smaller reptiles that creep among the decayed vegetable matter beneath our feet.

After passing *Gunong Tando,* the first ascent, elephants' tracks, which were there numerous, were no longer visible. The solitary scream of that singular caricature on the human species, the "*Oonka,*" and the note of the bird *Selanas* on Mount *Paradap,* were the last sounds of animal life the forest yielded.

After a short scramble, in which we were obliged in some places to draw ourselves up by the trees and roots, we attained the summit, from which we caught hasty glimpses through the rolling cloud, fast clearing away, of a magnificent prospect beneath. To the southward the states of *Segamat* and *Muar;* to the north-west the mountains of *Rumbowe* and *Serimenanti;* and to the north-east *Jompole* and part of *Pahang,* celebrated for its gold. Turning westwards lay the ruins of the ancient church of St. Paul's, on the flagstaff hill at Malacca, and part of the town itself; its bight and the sea coast from Mount Formosa to *Salengore,* the glittering and placid surface of the water enamelled with numerous verdant islets. The view inland presented a vast amphitheatre of thick foliage (with here and there slight bare patches of *sawah* and pasture land), thrown into various shades and tints by the rays of a setting sun.

The extreme apex of the mountain is formed of a block of greyish granite, surrounded by others, lying on a strip of table ground about 40 yards long by ten broad, on which grew some stunted trees, a few of the fir kind, some lichens and mountain shrubs, among which are found the *Petis Patis, Samoot,* the *Russam,* and *Pruik Krek;* the Malays were unable to tell the names of many of the shrubs, never having seen them in the valley.

A thunder cloud growling and flashing a thousand feet beneath us now interrupted the prospect; owing to its influcnce, probably, the weather had been sultry during the afternoon; the thermometer (Fahr.) although in this elevated situation not sinking below 76° at 4 P. M. at 7 P. M. sunk to 69°, and at half past five A. M. the following morning to its greatest depression $65\frac{1}{4}$. The height of the loftiest peak above the surface of the sea, as calculated by the thermometer and boiling water, is 5693 feet.

The storm gradually ascending the mountain's sides induced us to seek shelter under an extraordinary overhanging rock, a short way under the summit, called *Battu Seroodang.*

The thunder storm had abated and finally ceased a little after sunset, when a host of fire flies, sole possessors of these heights, contending with the stars in liquid brilliance, floated around us, now soaring to the loftiest peak (for we had taken up our bivouac for the night at the foot of the rock near the summit) now sinking and gradually lost, sparkling and twinkling as they went, in the dizzy depths below. The Malays who were with me, complained much of the cold during the night and particularly before sunrise; but a brisk walk down the mountain side,

which brought us in little more than three hours to *Gummi,* effectually did away with the cause of complaint.

Whether the mountain just described, or its namesake on *Pulo Percha* or Sumatra, called by Malays *Gunong Passaman,* or the Ophir of Bruce in *Sofala* on the *Mozambique* coast, or Jamison's Ophir on the S. E. coast of Africa, be the Ophir of Scripture, or not, must still remain matter of doubt.

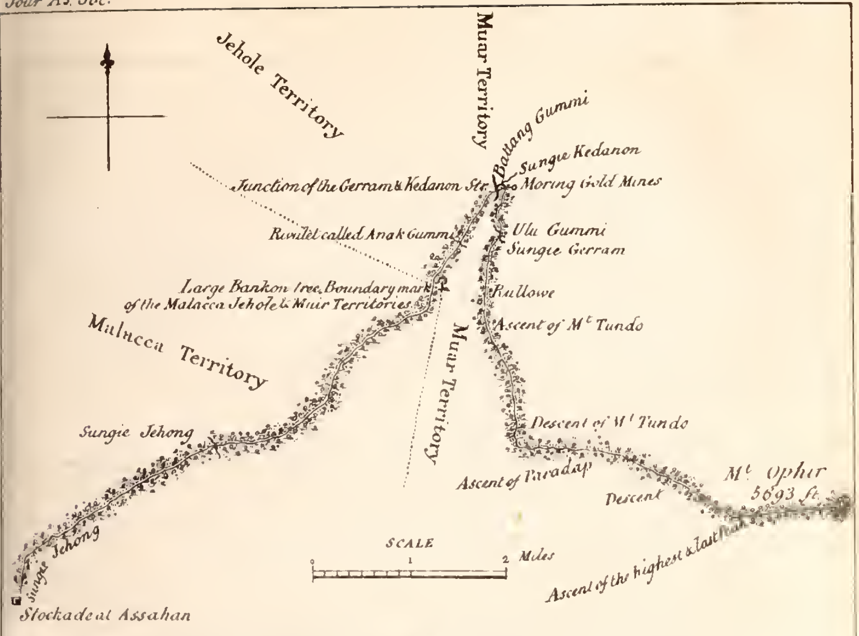
To the admirers of the marvellous I would recommend the careful perusal of San Mahmed's wonderful adventures, in his ascent to the summit of the mountain to entreat the hand of the enchanted princess of the rock for his master, Mahmed Sultan of Malacca, as contained in the Malayan historical work the *Sillálet-us-Salátin,* and the *Malay Annals.*

Note.—In justice to the mountain I have visited, suffice it here to quote two passages from Dr. Robinson's Theological Dictionary, Art. "Ophir." "Josephus says, that the country of Ophir is in the Indies, and is called the golden country. It is thought he means Chersonesus Aurea, known by the name of Malacca, a peninsula opposite to Sumatra." Lucas Holstenius after many inquiries thinks, "we must fix on India in general, or the city of Supar in the Celebes : again Lipenius, who has composed a treatise concerning the country of Ophir, places it beyond the Ganges at Malacca, Java, Sumatra, Siam, Bengal, Pegu, &c."

II.—*On the nest of the Tailor Bird. By Lieut.* T. Hutton, *37th Regt. N. I.*

In Professor Rennie's work on the Architecture of Birds, he gives two accounts of the manner in which the Tailor Bird constructs its nest, and as neither of these appear exactly to coincide with facts which have lately fallen under my observation, I have been induced to offer the following remarks for insertion in the Journal of the As. Soc. At page 258, the professor says:

"The most celebrated bird of this division is the one which in the East is par excellence named the Tailor bird (*Sylvia Sutoria,* Lath.) the description of whose performances we would be apt to suspect for an Oriental fiction, if we had not a number of the actual specimens to prove their rigid authenticity. We do suspect however that these very specimens have misled European naturalists a step beyond the truth in their accounts of its proceedings. 'The Tailor Bird,' says Darwin, 'will not trust its nest to the extremity of a slender twig, but makes one more advance in safety by fixing it to the leaf itself. It picks up a dead leaf and sews it to the side of a living one; its slender bill being its needle and its thread some fine fibres: the lining of the nest consists of feathers, gossamer and down; its eggs are white; the colour of the bird light yellow; its length three inches; its weight $\frac{3}{16}$ of an ounce, so that the materials of the nest and the weight



Route from Assahan to Mount Ophir: by Lt. Newbold.

Nest of the Tailor-Bird (*Sylvia rupicapilla*)

J. B Tassin. lith.

of the bird are not likely to draw down a habitation so slightly suspended. A nest of this bird is preserved in the British Museum*."

The second account runs thus:

"There are now three of such nests in the Museum, all of which certainly give some colour to the story of a dead leaf having been sewed to a living one; yet we have the authentic narrative of an eye witness of its operations which mentions nothing of this kind, but on the contrary serves to confirm our doubts. It will consequently be advisable to give this narrative in the language of the original observer, whose splendid figure we shall also take the liberty of copying. Comparing it with the Baya, which we have already described, he says: 'Equally curious in the structure of its nest, and far superior in the variety of its plumage is the Tailor Bird of Hindustan, so called from its instinctive ingenuity in forming its nest; it first selects a plant with large leaves, and then gathers cotton from the shrub, spins it to a thread by means of its long bill and slender feet, and then as with a needle, sews the leaves neatly together to conceal its nest. The Tailor Bird (*Motacilla sutoria*, Linn.) resembles some of the Humming birds at the Brazils in shape and colour; the hen is clothed in brown; but the plumage of the cock displays the varied tints of azure, purple, green and gold, so common in those American beauties. Often have I watched the progress of an industrious pair of Tailor birds in my garden, from their first choice of a plant until the completion of the nest and the enlargement of the young†.' "

In answer to these statements I shall make a few observations on the structure of two of these nests now in my possession, which were found in the garden of Capt. Hearsey, 2nd Local Horse.

The first was neatly formed of raw cotton and bits of cotton threads, woven strongly together, thickly lined with horse-hair and supported between two leaves on a twig of the *amaltás* tree *(cassia fistula)*. These two leaves were first placed longitudinally upon each other, and stitched in that position from the points to rather more than half way up the sides with a strong thread spun from the raw cotton by the bird, leaving the entrance to the nest, at the upper end, between the stalks of the leaves, at the point where they join the branch of the tree. Both of these leaves were of course green and living. Subsequently, however, they were blown down by a high wind, and being now withered, the nest appears enclosed between dead leaves.

Darwin's account therefore will be found to differ materially from mine, inasmuch as the bird neither makes use of a dead leaf in the construction of the nest, nor does it stitch it with fibres, but with strong cotton threads. The lining also of the nest, instead of being "feathers, gossamer and down," is solely of horse hair‡.

* Zoonomia, S. xvi. 13. 3. † Forbes' Oriental Memoirs, i. 55.

‡ Mr. S. P. Stacy has favored us with two specimens in which also the stitches are of spun cotton thread: the nest is of cotton and vegetable fibre.—Ed.

It appears to me that the nest described by DARWIN may have been originally constructed of living leaves, and that one of them through some accidental cause, being detached from the branch of the tree and becoming dry and withered, led to the belief of the dead and living leaves being sewed together—and indeed a case of this kind happened in Captain HEARSEY's garden, in consequence of which the bird forsook the nest.

I am moreover borne out in this idea by the figure given by PENNANT and copied by professor RENNIE, in which (as will be seen in the accompanying sketch*), the dead leaf appears to have been detached from a small stalk growing out of the same stem as the green leaf to which the nest is attached. This figure in very similar in appearance to the nest in my possession above described.

The second specimen is more satisfactory still, as in it were found an egg and two young birds nearly fledged†. The nest was at the end of a branch of the *Bhela (semecarpus anacardium)*, about two feet from the ground, and constructed of the same materials as the above, viz. raw cotton, cotton threads, also a little flax, and lined with horse-hair alone : the leaves are stitched together partly with thread prepared by the bird, and partly with spun thread, and so well concealed was it, that even after Captain HEARSEY had discovered it (by accident) he could scarcely find it again to shew to me. The young birds were placed with the nest in a trap cage, and thus we succeeded in capturing both the old birds.

I am however of opinion that this is not the kind to which the name of the Tailor Bird has hitherto been applied, but a distinct species.

The following is a description of it :

(SYLVIA RUFICAPILLA ? *Mihi.*) Length from the tip of the bill to the end of the tail, $5\frac{1}{2}$ inches in one specimen, and four inches in the other ; the tail of one is two inches in length, the other $1\frac{1}{2}$ inch, and both appear imperfect. Crown of the head fine rufous red, nape cinereous with a tinge of rufous ; back, scapulars, and rump and upper tail coverts, olive green ; wings light brown, with a tinge of green at the edges of the outer webs, and a tinge of the same on the upper wing coverts; tail of 12 feathers, narrow, the two middle ones longest, of a lighter brown than the wings and with a faint greenish tinge; the outer feather on each side the tail with a small white spot at the tip. All the under parts are white. On the sides of the throat is a small black stripe, which is only seen when the bird is in motion, wholly disappearing when in a state of rest. Legs slender and flesh coloured. Upper mandible dark horn colour, under one pale ; length of the bill half an inch ; irides rufous red.

They differ only in length.

* See "Architecture of Birds." Lib. Entertaining Knowledge. † Fig. 3.

The young birds are similar in colours, except that they are paler and the top of the head cinereous with a faint rufous tinge : bill yellowish.

The eggs are white, spotted, chiefly at the larger end, with tawny spots.

They are very lively little birds, exhibiting a good deal of the manner of the creeper tribe *(Certhia)*, carefully searching beneath every leaf, and into every chink and hole for insects, which they seize with great rapidity, flirting their tails up and down, and uttering a sharp reiterated cry.

Now it would follow, the accounts of DARWIN and FORBES being correct, that there is more than one species of bird in India, to which the specific name of *Sutoria* would apply : for instance DARWIN says, the Tailor bird is wholly light yellow, and in this LATHAM agrees with him ; while FORBES on the contrary declares it to vie in colours with the humming birds of the Brazils. It appears to me however that the latter author has confounded the tailor bird with the purpled creeper, *(Certhia purpurata,* LATH), which is the only bird I can remember at all approaching his description. The nest of the purpled creeper is however to me unknown.

That there is more than one species which sews the leaves of plants together to support and conceal its nests, I am almost certain, as a pair of birds, larger than those I have described, have been several times seen frequenting large-leafed plants, among which were discovered the commencement of one or two nests which had been abandoned, apparently from the leaves being blown asunder almost as soon as sewed together by the strong S.W. winds which prevail here. These birds were brown above and dirty white beneath.

The purpled creepers are now becoming plentiful in gardens here, and as I shall pay attention to their habits, and watch them closely, I am in hopes I shall be able to ascertain their method of constructing their nests also.

The description which approaches nearest to my specimens, is that of the "Long Tailed Warbler" of LATHAM ; viz. top of the head pale rufous, hind part of the neck, back, rump, wing coverts and tail, pale olive green ; quills olive brown, tail long, slender, composed of narrow feathers ; the two middle ones as long as the body. Inhabits China.

This is so near, that I can consider mine as none other. I do not perceive a specific name affixed to it, and have therefore given it that of "Ruficapilla." This however can easily be dropped, should the bird have been already *christened.*

NOTE. As the two first figures referred to by Lt. H. will be found in the "Architecture of Birds of the Library of Entertaining Knowledge, we have omitted them : the author's own sketch, No. 3, is inserted in plate xviii.—ED.

III.—*An Inquiry into the Laws governing the two great powers, Attraction and Repulsion, as operating in the Aggregation and Combination of Atoms. By* Julius Jeffreys, Esq.

[*Continued from page* 464.]

Moreover, there is another source for the sensible heat, in the sudden and forcible compression, which the circumjacent air undergoes, at the moment of the explosion, from which condensation the air itself must evolve heat. The explosion of euchlorine gas, with an evolution of heat, is perhaps a stronger objection, than the former, for it is not attended with a new combination of the elements. This is, however, an objection rather to one of the laws of heat, namely, its becoming latent, than to its materiality, against which, in fact, it is only an indirect objection, by shewing the law, that heat becomes latent in a change to a rarer state, not to be universal. But the whole doctrine of *latent* heat might be imperfect, and yet not invalidate the *materiality* of heat. Nor should an individual exception (supposing it to be such) be considered as subverting a doctrine of so perfect, and almost universal application, as is that of latent heat; much less then does it refute the *material* doctrine, which is not necessarily dependent on the former.

The manner however, in which the above experiment is made, appears to me, as lessening greatly its force, as an exception to the doctrine of latent heat. A small quantity of the gas is used over mercury. As this liquid is incompressible, and so weighty as not to be readily susceptible of sudden motion, it must offer a very great resistance to the instantaneous expansion of the gas, and by this re-action may force out sufficient heat and light to become visible (i. e. a spark or flash); but after the expansion is finished, if much of the gas had been used, it is not improbable, that a fall of temperature would have been evident, in a thermometer introduced.

4. The fact that some gases combine with each other, and form solids, with but a small rise of temperature, as when ammonia combines with many gases, is an objection the reverse of the former; and like it is an exception to the doctrine of latent heat.

It may however be thus explained; that the affinity of such gases, both for heat, and for each other, is so great, that it condenses most of their heat, without evolving it; in the same manner, as when oxygen and nitrogen gases are condensed in nitre.

5. The contraction of clay by great heat, and of water in advancing from 32° to 40° of Fahrenheit, have been considered as objections to the law of expansion, and therefore to this doctrine of heat. The

former however may arise from the great attraction of clay for water; which only the greatest heat can drive off; and of the latter the usual explanation, that it arises from the loss of polarity, which the particles had assumed, appears quite satisfactory. If these be objections, they apply, at least as much, to the theory of vibration; for even were it possible, that an increase of vibration in particles could give rise to expansion, these experiments would show increase of vibration attended with contraction.

6. The combinations and decompositions often effected by the rays of the sun, are certainly not always conformable to the laws of this doctrine of heat; but neither are they to any other doctrine.

7. It has been objected to heat being the cause of elasticity in gases; that this force varies as the density, although in the condensation of gases, much heat is evolved. But this experiment only shews, that, in the condensation of gases, part of their heat is evolved; which if it remained would cause their elasticity to vary in a higher ratio than that of the density.

8. Lastly, it has been objected to the materiality of heat, that notwithstanding the most accurate experiments have been made, it has always been found impossible to ascertain, that it has weight.

This objection however is not valid, since it has neither been possible to weigh light, though few will doubt its materiality, or the materiality of some ether in which its phenomena are seated; which hypothesis merely removes the difficulty of its materiality one step farther. It has also been very justly remarked by a great philosopher, whom I have already quoted, that if this etherial fluid be supposed as much lighter than hydrogen gas, as the latter is than the metal platinum, it could not probably be ascertained to have weight by any means which are known*.

The above are most of the facts, which are considered as objections to the material doctrine of heat, many of which may be sufficiently explained.

Much more may be said in support of the doctrine.

As the materiality of light can scarcely be questioned, since Sir Isaac Newton has so ably argued in proof of it, and since on it he has built his system of optics, which could not be founded on any other doctrine, the striking analogy between it and heat, must strongly point out the materiality of the latter. Heat, like light, is radiated from the sun; like light, it travels with exceeding velocity; like light, it is radiated by many bodies, is reflected, is refracted; and according to Berard, is sometimes, like light, polarized. From analogy so strik-

* Sir H. Davy's Elements of Chemical Philosophy, p. 97.

ing as this, some philosophers have been induced to consider them as modifications of the same matter; or that light, by its actions on bodies, produces the phenomena of heat. But of late years sufficient evidence has been brought of their being separate substances. The experiments of Herschel, and Sir H. Englefield, shewing that heat is not quite so much refracted in the prismatic spectrum as light, whence that much heat is found within the red ray, are a strong proof of this. Nor do the later experiments of Berard (supposing them more correct), which would prove, that the intensity of the heat within the red ray is less than was represented by these philosophers, at all invalidate the argument. For it is only necessary to shew, that *any* heat may travel from the sun, independent of light, to prove a difference between them.

Herschel has also shewn*, that if the red ray be thrown on red glass, the light is transmitted, but nearly $\frac{7}{10}$ of the heat are detained; and hence, that this appears incompatible with the supposition that the ray is *homogeneous;* for were it so, the heat transmitted should have corresponded with the light.

The rays from a fire being differently transmitted by glass (those of light being transmitted, but those of heat being most of them detained) is an argument of a similar nature.

Heat is radiated without light by many bodies below certain temperatures, and others, as phosphori, radiate light without heat.

The analogy between light and heat is so striking, that since the former is material, it is almost necessary to consider the latter as such, and yet there is sufficient evidence of a distinction between them.

It is evident from his writings†, that Sir Isaac Newton was of opinion, that the phenomena of heat arise from the action of light on bodies, causing vibrations in a "subtle medium" in them. But it is equally plain that by heat he meant, those phenomena only which are apparent to the senses and commonly called heat. From the very imperfect state of chemical philosophy in his day, the doctrine of calorific repulsion was scarcely taught; and most of the experiments, in proof of the materiality of heat, have been since performed.

This great man has by several passages, especially by some in the 18th query in his Treatise on Optics, suggested the existence of a *highly elastic subtle* fluid, so nearly allied to the matter of calorific repulsion of the present day, that part of this query, with but the smallest modification, is an accurate description of the latter. "If," observes

* Philosophical Transactions for 1800.

† Optics, Query 18.

Sir Isaac Newton, " in two large, tall, cylindrical, vessels of glass inverted, two little thermometers be suspended, so as not to touch the vessels, and the air be drawn out of one of these vessels, and these vessels, thus prepared, be carried out of a cold place into a warm one, the thermometer in vacuo will grow warm as much, and almost as soon, as the thermometer which is not in vacuo. And when the vessels are carried back into the cold place, the thermometer in vacuo will grow cold, almost as soon as the other thermometer."

" Is not the heat of the warm room conveyed through the vacuum by the vibrations of a much subtiler medium than air, which, after the air was drawn out, remained in the vacuum ? and is not this medium the same with that medium by which light is reflected and refracted ? And do not hot bodies communicate their heat to contiguous cold ones, by the vibrations of this medium propagated from them into the cold ones ? And is not this medium exceedingly more rare and subtle than air, and exceedingly more elastic and active ? And doth it not readily pervade all bodies* ?"

If to these questions were added this one, " And is it not attracted by all particles of all bodies, but with various degrees of force in each ?" This medium would at once form the matter of calorific repulsion, and the phenomena of moving heat would arise from its motion and vibration, which must necessarily happen, both from its various affinities, and from its own elasticity tending to an equilibrium of force. Caloric, like this medium, exists, from the minuteness and mutual elasticity of its particles, in what is a vacuum to other bodies. By

* It is a singular circumstance, that some late authors have quoted this passage in order to shew, that Newton was doubtful about the nature of light, and seemed to accord with the theory of tremulous motions in an universal ether, rather than of moving particles emitted from bodies. It is certainly incredible that Sir I. Newton should at the end of his Treatise on Optics, introduce an opinion which would thus overthrow the whole doctrine he had been labouring to establish. Nor is it more probable that entertaining such an opinion, he should have written the 14th section of the 1st book of his Principia, which with it would be nothing more than vain and idle speculation. But the words of the query convey no such meaning. They express an impression upon the author's mind, that the phenomena of refraction, and reflection, are not the effect of attraction or repulsion exercised by the particles of the grosser bodies, commonly called mediums, upon the particles of light, but those of a very far more subtle medium interspersed between the particles of the above-mentioned bodies. Nothing is said implying that this subtle fluid is light itself; on the contrary it is spoken of in a totally distinct character, as a medium, that is, as a substance having a boundary through which light finds a passage, or from the surface of which it is reflected.

the motion and vibration of caloric, or this medium, bodies become of equal temperature. By the atmosphere of caloric round the atoms of bodies, may be effected the reflection and refraction of light, in like manner as this medium is supposed to operate. Caloric, like this medium, is exceedingly more rare and subtle than air, and exceedingly more elastic and active ; for it loses much of its rarity, subtlety, and elasticity when attracted by the gross atoms of gases, which it encompasses, endows with mutual repulsion, and in fact transforms into elastic air. Caloric, like this medium, readily pervades all bodies.

Is not caloric therefore no other than this medium ? and hence, material ?

[Lastly, although we have above seen that a vibration or other motion of the gross particles of bodies cannot in any way account for the *dilating* power of caloric, it does not at all follow that the phenomena of *sensible heat* may not depend on a peculiar condition of the *particles of the matter of heat itself*, such as vibrations in *them* of different degrees of intensity. Hence the absolute quantity of the matter of heat may not always be indicated by the phenomena of sensible heat. And in sudden or violent actions, as those of friction, detonation, and combustion, these phenomena may thus be considerably increased without any increase in the absolute quantity of the matter of heat. In this manner the two leading hypotheses may be united, and the chief difficulties attendant on each being removed, a doctrine, deserving of reception, may be established as a well-digested theory of caloric, in its characters of an expanding and heating medium.]

Having now, I trust, shewn, that the opponent force to the attraction of atoms cannot be a repulsive power inherent in them, but, that it arises from the agency of heat; and that heat cannot be considered as arising from a vibrating motion in the atoms of bodies themselves, but that it is a very subtle fluid, whose particles are possessed of two powers, always inherent in them ; namely, that of repelling each other, and that of attracting all other matter :—having shewn this, the next inquiry which would present itself, is, into the laws governing these two powers of heat, were such a direct inquiry possible.

From the extreme minuteness of the particles of heat, and from their attracting powerfully the atoms of all other matter, it will follow, that every atom of the latter is surrounded by numerous particles of the former ; all of which particles of heat, must tend with great force towards the centre of the atom they surround, and would be in absolute contact with each other, did not their other power (namely, the repulsion which operates between the particles of heat themselves,)

prevent their actual contact. Hence they do not form dense masses, but atmospheres round all the atoms of bodies, and endow them with mutual elasticity, which operating against the cohesion of bodies prevents the contact of their atoms.

From this it is manifest, that the mutual repulsion between the particles of heat themselves and their attraction for the atoms of all other matter, are forces which operate against each other; the former tending to expand heat, and the latter forcing its particles near to each other by collecting it around the atoms of bodies in the form of atmospheres, the density of which will vary as the force by which they are detained round atoms varies.

Since, then, these two powers of heat are always operating against each other, no opportunity can be afforded of measuring either of them as a simple force. Since also the atmospheres of heat are always from other causes subjected to compression, the only force, which can be judged of, is a compound repulsion; namely, the elastic force of the particles of heat modified by their other power, attraction, condensing them round atoms.

The ratio in which this compound repulsion varies, must greatly depend on the *force* with which the atmospheres of heat are detained by atoms, and will therefore probably differ in all bodies.

It is however of great importance to obtain so much knowledge of its properties, as may account for the stability of atoms which takes place in the formation of bodies, &c. which must arise from an equilibrium subsisting between the compound repulsion above-mentioned, and the mutual attraction between the atoms themselves.

This investigation, though essentially necessary to a sound explanation of the constitution of bodies in their various states, has not hitherto, I believe, ever been carried on. I shall endeavour to effect it by pursuing the following inquiries:

1st. Whether the repulsion from heat varies in a less inverse ratio of the distance than the attraction of atoms.

2ndly. Whether it varies in the same inverse ratio as the attraction.

And, having shewn that neither of these laws can take place in nature, I shall proceed in a second division to consider the important proposition which remains; viz.

That the force of repulsion with which heat endows atoms, varies in a greater inverse ratio of the distance than the attraction; and to demonstrate that all states and combinations of bodies are satisfactorily accounted for by this law.

1st. Whether the repulsion from heat varies in a less inverse ratio of the distance than the attraction between the atoms of the bodies it pervades.

If this be admitted with respect to the law of repulsion, since attraction varies inversely as the square of the distance, let the repulsive force vary inversely as the distance. And since these two forces must be in equilibrio in any solid whose atoms are at rest, let the following represent the forces operating between any two atoms, A and B, at various distances; and let the atoms be placed at any distance 3, at which point the forces must therefore be in equilibrio.

Distances.	1	2	3	4	5	&c.
Repulsion,	96 :	48 :	32 :	24 :	19,2 :	&c.
	A		B			
Attraction,	288 :	72 :	32 :	18 :	11,5 :	&c.

Here it is plain, that at distance 3 these atoms can be stationary; but if by the slightest force or agitation they are made to approach each other in the smallest degree, as their mutual attraction becomes stronger than the repulsive force, and increases as they approach in a higher ratio, it is manifest, that A and B will come together, and remain in absolute contact.

Again, if A and B are separated in any degree beyond distance 3, they will instantly lose their adhesion, as now the attraction loses force in a greater ratio than the repulsion.

This law would in fact constitute what is called in mechanics an unstable equilibrium; and hence atoms of matter would soon be either in absolute contact or at infinite distances from each other.

Yet, however, in one of the ablest systems of chemical philosophy, which has ever appeared, we find the following passage; " From the very abrupt transition of steam, from a volume of 1700 to that of 1, without any material increase of pressure, one would be inclined to think, that the condensation of it was owing to the breaking of a spring rather than to the curbing of one." "The last however," says the author, " is the fact. The condensation arises from the action of affinity becoming superior to that of heat, by which the latter is overruled, but not weakened.

" As the approximation of the particles takes place, their repulsion increases from the condensation of the heat, but their affinity increases, it should seem, in a still greater ratio, till the approximation has attained a certain degree, when an equilibrium between those two powers takes place, and the liquid water is the result*."

* DALTON's New System of Chemical Philosophy, Part 1st, page 149.

This passage exactly proposes the above law, that as particles approach their affinity increases in a greater ratio than the repulsive force, or that the repulsive force varies in a less ratio than the attraction. The inadequacy of this explanation may at once be shewn. If, between the atoms of steam, the attraction has become greater than the repulsion, and if the attraction varies in a greater ratio, i. e. increases faster as the atoms approach than the repulsion, the particles must come into actual contact. The equilibrium spoken of in this quotation, can no more take place than between the forces of the atoms, A and B, in the diagram, should they be once within the point of unstable equilibrium.

It cannot then be a law of the repulsion of heat that it varies in a less inverse ratio than the attraction.

Secondly.—Whether the compound repulsion from heat varies in the same inverse ratio of the distance as the attraction of the atoms of the body.

Supposing it a law of repulsion that it varies in the same inverse ratio of the distance as the attraction, it is evident that if the two forces are equal at one distance, they will also be equal at any other ; and if one force be the greater at one distance, it will also be the greater at any other ; and therefore likewise, if one force be less than the other at one distance, the same force will be less at any other.

Let us apply this law to the explanation—

First.—Of the constitution of solids.

When any body passes from the liquid to the solid state, it is rightly supposed, that by the abstraction of heat, the attraction is enabled to bring the atoms of the fluid within the distance at which from the form and qualities of those atoms, solidity naturally subsists. But according to this law ; as the attraction was more powerful at the greater, it will also be at the smaller, distance ; and, in the solid, all the heat would either be expelled or so compressed, that the atoms would be in absolute contact, which certainly is not the case ; for all solids are capable of contraction.

Secondly.—Of the constitution of liquids. Although most philosophers admit the existence of an attraction between the atoms of liquids, yet many* consider the liquid state as depending solely on the pressure of the air ; without which, all bodies would either be solids or gases.

* Berthollet in his Chem. Statics. Translation by Lambert, page 352—And many others.

This Lavoisier himself has enforced. After some former remarks he continues thus* : " Whence it appears, that without this atmospheric pressure we should not have any permanent liquid, and should only see bodies in that state of existence in the very instant of melting; for the smallest addition of caloric would then instantly separate their particles, and dissipate them through the surrounding medium." This doctrine this great philosopher has supported by experiments on liquids placed in vacuo, which rapidly pass into vapor on the removal of atmospheric pressure.

Although most of these experiments appear to confirm the above doctrine, yet I may state certain objections which appear to me unanswerable. Though most liquids do pass into vapor under the exhausted receiver, yet there are some, such as concentrated sulphuric acid, which scarcely appear to do so. This acid (as is well known in what is named the freezing experiment) by its great attraction condenses aqueous vapor formed in an exhausted receiver, and thus preserves a partial vacuum. It not only remains in the liquid state itself, but also condenses the vapor from the vacuum.

Again. If even all liquids could be shown to vaporize at natural temperatures in vacuo, it would not be any proof of the doctrine, owing to the imperfect nature of the experiment itself. Any liquid under the pressure of the air, must soon be of the same temperature with the air, i. e. endeavour to part with heat with the same force: but as soon as the atmospheric pressure is removed, a great force, tending to expel heat from the liquid, is removed ; the effort therefore of the liquid to expel heat becomes less than before, and therefore less than the effort of the circumjacent air. The consequence of this must be, a continual passage of heat from the air to the liquid, and its vapor, which will make the evaporation unlimited. Were it possible to procure a receiver which should not be permeable to heat, there would soon be a limit to the evaporation of a liquid, and the receiver would doubtless remain exhausted. It is certainly true, that under such circumstances, water would not remain a liquid, and a small part of it would pass into vapor, most of it would become ice. But ether, alkohol, and other liquids which would resist freezing, would probably continue as liquids in a receiver impermeable to heat. The receiver of any air-pump is in a similar situation to that of a common pump; except that on the removal of the pressure, *heat* is forced into the former and *water* into the latter, by the very same force ; namely, the

* Elements of Chemistry, translated by Kerr, page 56.

pressure of the atmosphere. Hence it would appear, that the pressure of the atmosphere does not so materially affect the constitution of liquids, as is generally supposed ; for, although by compressing them with great force, it resists their passing into vapor, yet it at the same time endeavours to afford them the heat requisite for this transition, though doubtless with less force.

Let us now consider the constitution of a *liquid,* supposing the repulsion from heat and atttraction as varying in the same ratio.

And first.—In a liquid, these two forces could not be equal to each other at any one distance of the atoms ; for since they would also be equal at any other, no resistance whatsoever would be offered to any force, such as that of the atmosphere compressing the liquid into an absolutely dense mass, the atoms of which would be in contact. They would, in fact, constitute, what in mechanics is named an equilibrium of indifference, liable to be destroyed by the slightest extraneous force.

Again : the attraction could not be the greater force at any one distance, for it would also be greater at any other ; and much more then could no liquid exist, for there would be, besides external pressure, this additional force tending to condense the liquid, and no force to resist their action.

Lastly : if the repulsive force be greater than the attraction at one distance, it also will at any other, and this excess of the repulsion over the attraction, might be sufficient to resist also the pressure of the air ; and the constitution of a liquid might be considered as compatible with such a law. But let us examine this more minutely. If the pressure of the air were removed from a liquid, since the repulsion was so far superior to the attraction, it would necessarily expand the liquid without limit ; for it would, at any distance of the atoms, continue the more powerful force. But it has, I think, been above shewn, that there is no evidence of liquids expanding into vapors without any addition of heat. The vapor from a liquid in vacuo is expanded, both by heat assumed from the liquid and by heat forced in by the atmosphere without ; and yet the evaporation of most liquids in vacuo is not instantaneous, as it would be according to such a law. Of some, as sulphuric acid and certain oils, it is at most, exceedingly slow.

There is moreover evidence of the attraction in liquids becoming, on a small separation of their atoms, stronger than the repulsion ; for otherwise no attraction would be apparent in them, nor would their atoms ever be collected into spherical drops ; which can only be effected by the excess of the attraction over the expanding force. This

last is a two-fold argument ; for since, on a small separation of the atoms of liquids, their attraction becomes superior to the repulsive force, how is it possible that without any addition to it, this repulsive force should expand them into gases ? And again, since the attraction is the stronger force, when the particles are somewhat removed, if the two forces varied in the same ratio, it has been already shewn that no liquids could exist ; but atoms, so acted upon, must be reduced into masses absolutely dense.

The constitution of liquids then could not be accounted for, if the compound repulsion of heat be supposed to vary in the same ratio as the attraction.

Thirdly.—Of the constitution of gases.

When a liquid passes into the gaseous state, its atoms are so far separated from each other that their mutual attraction is much lessened, but from its great augmentation of bulk, the pressure it is subjected to is greatly increased. Hence, in a gas the chief force opposing expansion, is the pressure of the air ; and to enable it to resist this force, the repulsion must be so augmented as to exceed the attraction by a force equal to the pressure.

It is this excess of the expanding force over the attraction, which is alone capable of being measured.

The experiments of Mr. Boyle, as is well known, tended to shew that the density of gases varies as the compressing force ; and Newton proved that if this be true, the expanding force operating between the atoms, will be inversely as their distances.

But as only the excess of this force over the attraction is capable of measurement, it is plainly this excess of the repulsion which was shewn to vary inversely as the distance between atoms.

If, then, the repulsion from heat and attraction vary in the same ratio, and if this ratio be the inverse square of the distance, any difference between the two forces ought also to vary in the same ratio.

And although this difference in the experiment of these great philosophers, is seen to vary in a less ratio than the inverse square of the distance, yet it will not appear incompatible with this or even some higher power being the real ratio of the repulsion between the atoms of any gas, when it is remembered, that on increasing or lessening the density of a gas, by varying the compressing force ; in the one case much heat is given out, and in the other much is assumed. This must cause the expanding force apparently to vary in a far less inverse ratio, than it otherwise would, if heat did not pass out on increasing, or were not assumed on lessening, the density of a gas.

I am ready indeed to acknowledge, that it is not possible to prove from the constitution of a simple gas, that the two powers attraction and repulsion from heat do not vary in the same ratio ; for the effective repulsion, though (according to this law) superior to the attraction at every distance, may have its force limited by atmospheric compression.

Yet, however, since both in solids and liquids it has been proved that the two forces cannot vary in the same ratio, it may be concluded that they neither can, when a body has assumed the gaseous state, although from the peculiar nature of a gas, it may not be possible directly to prove this fact.

Fourthly.—Of the solution of solids in liquids.

Of all combinations none are more frequent, than the solution of solids in liquids ; and of all states no one is more remarkable, than that of many bodies in solution. Oftentimes a dense solid is disintegrated by the powerful affinity of a liquid ; and yet a very weak combination takes place. A combination, in which most of the characters of the bodies remain, contrary to a well known law of combination.

It is somewhat remarkable, that even BERTHOLLET, who has written very fully and ably on Chemical Statics, should have said very little in explanation of the weakness of the combination in many solutions. The two following are the chief passages in his work, which refer to this important question.

" Solution," he observes, " is therefore the effect of a power which can overcome the resistance of the force of cohesion, and the difference of specific gravity* : and again, " in reality it (the solvent) exercises a force similar to that of the affinity which produces combinations, and whose effect is limited, in the solution of a solid, by the force of cohesion, &c.†" The late Dr. MURRAY, while supporting his doctrine of mixed gases, has written more definitely on this subject. " In the solution of a solid," observes this able author, " there are opposed the force of affinity between the solid substance and the solvent, and the cohesion of the solid retaining the solid particles in aggregation ‡." And again he writes : " In the solution of salts in water, the attraction exerted is merely sufficient to give fluidity to the solid and to counteract its cohesion and specific gravity ; the properties are not altered, &c.§"

* Chemical Statics, translated by LAMBERT, vol. i. 20.

† Ditto, vol. i. 295.

‡ System of Chemistry, vol. i. 40.

§ Ditto, p. 41.

These explanations, however, though perhaps at first sight apparently satisfactory, will not account for the imperfect combinations which generally take place in solution.

It will not be difficult to shew that the cohesion and greater specific gravity of the solid. cannot be the forces, which prevent an intimate combination from taking place. When once the attraction for the atoms of the liquid has overcome these forces, the atoms of salt and water would come into absolute contact and form a most intimate combination.

This is evident from the following considerations :—that, as the atoms of salt separate from each other, their attraction decreases. But, as they approach those of the water, their attraction for the latter, increases in as great a ratio as their own cohesion decreases. Hence, since the attraction for the atoms of the water, when comparatively at a distance from those of the salt, is superior in force to the cohesion of the latter, when near to each other,—much more then would the attraction for the water exceed the cohesion of the salt, when the atoms of the salt have separated from each other, but approached those of the water.

The difference of specific gravity in itself, but an inconsiderable force, does not increase. The effect resulting from all these forces would be, an actual contact of the atoms of the solid with those of the fluid. How much more then, an intimate combination.

This effect can only be prevented, by the repulsive force of the heat ; which must operate between the atoms of a solid and those of a liquid, in like manner as between any other atoms. But if the attraction is superior to the repulsion at one distance, it will also be at any other, (according to this law ;) and this superiority of the attraction will increase as the atoms of the solid approach those of the liquid. The intimacy of the combination therefore cannot be prevented by the repulsion, if being already inferior to the attraction, it varies in the same ratio with it.

The solution of solids in liquids and the weak resulting combinations, cannot then be explained, if the force of repulsion be supposed to vary in the same ratio as the attraction. Neither could the *mere condensation* of many gases by liquids be accounted for, as might also be proved.

Fifthly.—Of the solution of liquids in gases.

Although various theories have been proposed, in explanation of the solution of liquids, in gaseous fluids, yet no one is altogether satisfac-

tory, for to each objections may be brought. I shall briefly review them separately, and then inquire whether this fact can be explained, on the supposition, that the repulsive force of heat varies in the same ratio as the attraction. The inquiry will be directed especially to the solution of water in the atmosphere, as being the most familiar and striking instance.

First, that aqueous vapor exists in the atmosphere, solely by its own expansive force. This hypothesis has had two forms. Mr. Dalton has supposed, that between different gases the attraction and repulsive force of the atoms are so nearly equal, that gases are neutral towards each other* ; and therefore, that the air has no effect on its hygrometric vapor, which would exist from its own elasticity equally, whether the air be present or not.

Several objections have been brought against this theory, some of which Mr. Dalton has very ably and ingeniously answered. But there are others, which *cannot* be answered. One of them appears to me alone so weighty an objection, as to render it unnecessary to enter into any besides it,—namely, that if vapor, existing in the atmosphere, were perfectly neutral towards it, then certainly the *density*, and not the *bulk* of the atmosphere, would be increased by the presence of the vapor. But Newton has proved that the contrary takes place.

Aqueous vapor increases the bulk of the air, and even so much as to *lessen* its density.

If the vapor and air are quite neutral towards each other, how could the elastic force of the former act against the atoms of the air so as to separate them, which must be the case ; for otherwise the density would be increased in proportion to the vapor present, instead of being diminished ?

Mr. Dalton has endeavoured to answer this objection by the following comparison, which I shall attempt to examine, inasmuch as I am persuaded it is not applicable, though it has been admitted as such by many ; and I may state a refutation of it, which has presented itself to me, and which I do not think has hitherto been proposed.

"Let" (he says) "a tall cylindrical vessel of glass containing dry air be inverted over mercury ; and a portion of the air drawn out by a syphon, until an equilibrium of pressure is established within and without ; let a small portion of water, ether, &c. be then thrown up into the vessel ; the vapor rises and occupies the interstices of the air as a void ; but what is the obvious consequence" ? "Why," he says, "the surface of the mercury being now pressed both by the dry air

* New System of Chemical Philosophy, p. 162.

and by the new raised vapor, is more pressed within than without, and an enlargement of the volume of air is unavoidable in order to restore the equilibrium. Again, in the open air; suppose there were no aqueous atmosphere round the earth, only an azotic one equal to twenty-three inches of mercury, and an oxygenous one equal to six inches, " the air being thus perfectly dry, evaporation would commence with great speed. The vapor first formed being constantly urged to ascend by that below, and as constantly resisted by the air, must in the first instance dilate the other two atmospheres, &c.*"

To this I may object, that in the experiment made on the gases over mercury, this liquid presses on the aqueous vapor as well as on the air; and therefore both of them can re-act against it, and will depress it more than either singly. But in the atmosphere the superincumbent atoms of oxygen and nitrogen (which are according to the theory perfectly neutral towards the vapor), being the compressing force, cannot press on the vapor, and therefore cannot be re-acted against.

Hygrometric vapor could not therefore cause the atmosphere to expand as the vapor does the air in the experiment; for the former vapor does not act on the compressing force of the atmosphere as the latter does on the mercury.

The impact of the vapor against the atoms of the air, would be so transient and occasional (owing to the minuteness and rarity of the atoms), that it is unworthy of notice as an opposition to the rise of the vapor.

Again, Mr. Dalton continues thus: " At last, when all the vapor has ascended that the temperature will admit of, the aqueous atmosphere attains an equilibrium; it no longer presses upon the other two, but upon the earth; the others return to the original density and pressure throughout." To this I may observe;—it is very true, that the others would return to their original density and pressure, but this is an admission which itself destroys the supposed analogy of the experiments, in which, while the vapor is present, the air does *not* return to its original density. Mr. Dalton continues: " In this case it is true, there would not be any augmentation of volume, when aqueous vapor was combined with the air; humidity would increase the weight of the congregated atmospheres, but diminish their specific gravity, under a given pressure." To this it may be replied. It is

* Dalton's New System of Chemical Philosophy, p. 162.

certainly true, that when aqueous vapor was added to the air, it would not (according to this doctrine) increase its volume, but this is likewise an admission which would destroy the analogy of the experiment ; and it even forms an impossibility, with the latter part of the sentence. How is it possible that hygrometric vapor (which is an addition of matter) should lessen the specific gravity of the air, and yet not increase its volume ?

The truth, in short, is, that according to this theory, the hygrometric vapor could not increase the volume of the air, but then it must increase the specific gravity. And since this is contrary to the physical fact, it is manifest, this theory is inadmissible.

Dr. THOMSON has adopted the other form of the hypothesis, that liquids pass into vapor solely by their expansive power. He supposes, that the vapor and air are not neutral (as was once Mr. DALTON'S opinion), but elastic towards each other ; and therefore, that water passes into vapor, although repelled by the air. The following objections will, I think, shew, that this theory will not afford a satisfactory explanation of the fact. It is plain, that the mutual elasticity of the air and vapor must be inferior to the elastic force of the vapor of water, otherwise the latter could not pass into vapor. But the elastic force of aqueous vapor, at most natural temperatures, is not equal to more, than $\frac{1}{30}$ of the pressure of the air, which pressure must be supported by the water, and therefore must press on it with a force far superior to the elasticity of vapor, at any natural temperature. And even, if water could pass into vapor, this vapor, being lighter than air, would separate from it and float above, since it repels the air, unless this repulsion be exceedingly weak.

The experiments of PICTET and of DE LUC, shewing that evaporation takes place quite as readily in vacuo, are no proofs, that evaporation in the air arises solely from the elastic force of water. They only shew (what no one will deny) that the expanding power in water greatly *aids* its evaporation. Water, under the atmosphere, is compressed with a force 30 times as great as the strength of its vapor (at most natural temperatures) ; there must then exist an attraction between it and the air, to enable it to evaporate as much as it does in vacuo, when no force is opposing the expansion.

Lastly then, it would appear that the hygrometric vapor must be attracted by the air ; and of an attraction between air and water many presumptive proofs have been already adduced.

But, according to the law, that attraction and the force of repulsion vary in the same ratio, if the former be superior to the latter force,

between the atoms of air and water when at a distance, it will also be superior when they are near to each other. Hence this superior attraction would bring the atoms of the two fluids into absolute contact, much more then, into intimate combination.

But hygrometric vapor is in a very weak state of combination. The mere solution of liquids in gases cannot then be explained, if the two forces are supposed to vary in the same ratio.

Sixthly. Of the constitution of mixed aerial fluids. The fact that all gaseous fluids, however different their specific gravities, mix when placed together, has been already noticed in a former part of this essay. I shall now attempt a brief inquiry into the various explanations proposed, to account for this phenomenon. These have been applied chiefly to the constitution of the atmosphere ; it being a remarkable instance of a mixture, or solution, of gases in each other.

When treating of attraction, I endeavoured to prove, that between all gaseous fluids an attraction is exerted, with more or less force, at all distances.

That the atmospheres of heat round atoms, must endow them with mutual elasticity, is itself evident ; and is proved by the fact, that compound atoms are separated by an addition of heat, as is evinced in the decomposition of bodies by heat.

I shall therefore consider both forces, as operating between all atoms of gases; and inquire whether the nature of mixed gases, can be explained, according to the law, that attraction and the force of repulsion vary in the same ratio ; supposing, first, that these two forces are equal between gases ; or secondly, that the repulsion is superior ; or thirdly, that the attraction is superior.

1.—If between mixed gases, the attraction and force of repulsion are equal.

Mr. Dalton was formerly of opinion, that mixed gases neither attracted nor repelled each other ; and he explained the mixture of gases, by their own elasticity expanding each, which occupied the whole space between the atoms of the other, as if it were a void.

This very ingenious theory, which in many respects would give a sufficient mechanical explanation of mixed * gases, has, as is well known, been the subject of various discussions. Among others, the following objections of Berthollet, and Dr. Murray, are doubtless insuperable.

* It has been already shewn under a former head, that this theory cannot afford even a mechanical explanation of the solution of water in the atmosphere.

I shall quote the words of this last author, as being concise. "The repulsion between the particles of any individual gas, is owing to the operation of caloric, and is a necessary attribute of the form in which it exists; and why should there not be the same repulsion between the particles of two bodies in this form? What cause can counteract it, but a chemical attraction exerted between them?" "Besides, if there is no repulsion between the particles of different gases, as Mr. Dalton conceives, what prevents them from entering into combinations, when they approach within short distances, as they must frequently do in the internal movements of a mixed elastic fluid? And if there exists no mutual attraction, how are they under any circumstances, as, for example, by compression, or elevation of temperature, brought to combine? It may be added, that were Mr. Dalton's hypothesis just, two elastic fluids ought, in every case, to diffuse themselves in any space, and mix equally, with the utmost rapidity, each being as a vacuum to every other. Yet this facility of mixing is much dependent on their specific gravity." In many cases it is very gradual*.

Mr. Dalton afterwards did somewhat modify this doctrine. He supposed, that both attraction and the force of repulsion, operate between different gases; but that these forces are so nearly equal, as to have no effect in producing the mixture†.

Many objections against the former doctrine are thus obviated, and the spirit of the theory is preserved‡.

* Mr. Dalton endeavoured to explain this objection away, by an ingenious comparison. Page 175. He argues, that, if a ball of lead, which falls through the air at any given rate, be divided into numerous atoms, it will descend with far less velocity (for gravity increases as the cube of the diameter of any sphere, but the resistance only as the square of the diameter), and therefore that atoms of air must meet with very great resistance; and hence the slowness of the mixture. This is surely not a just comparison; for the atoms of lead are not resisted merely by absolute impact against atoms of air themselves, but by the atmospheres of heat round atoms which fill the void space between them, and must be elastic towards particles of lead, as towards any other particles. If these atmospheres were removed, and only the atoms of the air itself remained (they being kept asunder by some inherent repulsive force, which in conformity with the theory in question, did not operate against the lead), then the lead would probably fall with at least equal velocity, by being extremely divided; as its atoms might descend unobstructed, the air being almost a vacuum to them; for its own atoms probably do not occupy more than $\frac{1}{2000}$ of the whole space. For this same reason, two gases ought to mix with the utmost rapidity: the actual impacts of their atoms themselves being very few. But since they do not mix with such rapidity, they cannot be mutually inelastic.

† New System of Chemical Philosophy, p. 162.

‡ Let it be however kept in mind, that this theory cannot explain the evapora-

To this, however, I may state an objection of another nature, and no less powerful. If these two powers are so equal at every distance, as to neutralize each other, what must be the effect of the smallest addition or abstraction of heat ?

In the one case, repulsion becoming the stronger force, the gases must be totally separated. In the other, the attraction predominating will bring the atoms into contact, much more then into intimate combination.

2. Secondly, That between mixed gases the repulsive force is stronger than the attraction. Under this head may perhaps be placed the last modification of Mr. Dalton's theory. He admits of gases being mutually repellent, but lays down the following maxim on which he explains the mixture. "That every species of pure elastic fluid, has it particles globular and all of a size. But that no two species agree in the size of their particles, the pressure and temperature being the same*."

Hence Mr. Dalton argued, that in a pure gas the atoms being all of a size can remain at rest, as the pressure must be equal throughout. But when a gas of larger atoms is placed on the former, that the pressure of their atoms owing to a difference of size will be irregular and unequal : and that therefore an intestine motion must ensue, until, the gases having mixed, each can rest on the same base.

Even if the atoms of bodies endowed with their atmospheres of heat were spherical, it is very questionable whether the above doctrine, though evincing much ingenuity, be really applicable.

It is difficult to say what would be the effect of spheres of different sizes pressing on each other. But the atmospheres of heat round atoms are highly elastic, and hence do not press on each other by single points only, as inelastic spheres would ; but must assume some form requisite for general and regular contact ; without mixing. Thus if a long hollow cylinder placed perpendicularly, and closed at the upper end, have the air of a few inches from the top heated ; the atoms of the heated air being enlarged (it might be greatly), and according to Mr. Dalton's theory, pressing unequally on those below, a mixture ought to take place. The heated air ought to descend and diffuse itself completely among the cold air. There is little doubt, however, that no such occurrence would take place ; the heated air would continue above. But let the cylinder be inverted, and the heated air will rise

tion of water, and its lessening the density of the atmosphere. The objections stated under that head still remain.

* New System of Chemical Philosophy, p. 189.

rapidly ; and, even then, a great part will pass through the cold air without mixing with it ; as is plain from the fact, that the hottest air in theatres and heated chambers, is near the ceiling, though it receives its heat below. Yet, in a mechanical point of view, the volumes of air of different temperatures, precisely agree with the different gases of the same temperature, mentioned in the supposition, as far as having their atoms of different sizes.

Dr. THOMSON rejects both Mr. DALTON's and BERTHOLLET's explanation of mixed gases. The opinion which he holds, may be brought under this head. In his System of Chemistry he states it in the following words : " I conceive, that when two gases are mixed, the particles of each are beyond the sphere of the affinity of the particles of the other. If the elasticity be owing to the action of heat, it seems to follow as a consequence, that different gases must be mutually elastic towards each other. But I think that the elasticity itself is sufficient to account for this mixture taking place, without being under the necessity of having recourse to the hypothesis of DALTON*."

To this doctrine, I may be permitted to object, that since the atoms of any simple homogeneous gas, cannot be supposed continually to circulate, if heterogeneous are mutually repellent†, like homogeneous atoms, why should a mixture take place between gases which are of the *same* specific gravity ? But between gases of *different* specific gravity, much less, then, could any mixture take place ! Lest it should be supposed that difference of gravity in gases may depend merely on their ultimate atoms being of different *sizes*, but of the same specific gravity, the atom of oxygen, for instance, being 8 times as large as the atom of hydrogen, let it be remembered, that although their *ultimate* atoms might have the same specific gravity, yet when endowed, and hence enlarged, with heat, their relative size is greatly altered, the atom of hydrogen becomes twice the size of that of oxygen, and therefore has only $\frac{1}{16}$th the specific weight.

There would be no more reason for gases, even of the same specific gravity (supposing such), to undergo a mixture, than for any simple homogeneous gas to have circulation among its atoms continually ; and still less should gases of different specific gravity mix ; and should the latter already be mixed, surely they would in a short time separate. It does not appear then, from all that has been stated, if the

* System of Chemistry, last Edition, vol. iii. p. 35.

† By this expression I mean of course the gases having an effective repulsion between them.

repulsion be superior to, and vary in, the same ratio as the attraction, that the constitution of mixed gases could be accounted for.

3. Thirdly, That between gases, the repulsive force is inferior to the attraction.

After having urged the analogy of a solution of a salt in water, Dr. Murray observes: "It may equally be concluded, that such weak attractions may be exerted between aeriform bodies,—attractions sufficient to counteract their elasticity and difference of specific gravity, without being sufficiently energetic to cause an intimate combination. And this principle explains the constitution of the atmosphere. An attraction of this kind, may be exerted between the particles of oxygen and nitrogen gases, may counteract the difference of their specific gravities, and prevent them from separating from each other; and thus may be accounted for the two facts, which on former hypotheses appeared incompatible, the uniformity of the composition of atmospheric air, and its having no properties different from those of the gases of which it is composed*."

Under a former head† I have shewn, that the explanation which Dr. Murray has given, of a solution of a salt in water is not correct; and therefore the analogy does not hold good between it, as stated, and a mixture of gases. Although the above passage may appear to account sufficiently for a mixture of gases, it will not admit of a close investigation. It will be easy to shew from their writings, that many authors have reasoned, as if attraction and repulsion were supposed to vary in the same ratio, though none have expressed a clear and direct opinion concerning them.

If then (according to this law‡) there exists "a weak attraction sufficient to counteract the elasticity" of gases at any distance, however great, it will also be able to counteract the elasticity at any less distance, however small; and hence, of necessity, to bring the atoms of one gas into contact with those of the other; before which an intimate combination would take place.

Supposing then the repulsive force, operating between gases, to be weaker than their attraction, and to vary in the same ratio with it, the mixture of gases could not be explained, since a perfect combination would ensue on their being presented to each other.

* System of Chemistry, vol. ii. p. 41.

† "The solution of solids in liquids."

‡ That the two forces vary in the same ratio.

Part II.—*Division* 2.

The minute inquiry which I have endeavoured to pursue into the laws of repulsion, I trust has shewn, that this force cannot vary either in a less, or the same, inverse ratio of the distance as the attraction.

That this inquiry has not hitherto been strictly pursued, by the ablest writers on chemical philosophy, is evident from the numerous, and even opposite doctrines, which have been laid down to explain the various states, and degrees of combination, in which bodies exist ; and also from numerous passages throughout their writings. Thus the following quotation from the great Lavoisier will shew at once, that (from want of a sufficient investigation) he reasoned as if the two opponent forces to each other, attraction, and the repulsion from heat, varied in the same ratio.

" We have already seen," observes this eminent writer, " that the same body becomes solid or fluid, or aeriform, according to the quantity of caloric, by which it is penetrated ; or more strictly, accordingly as the repulsive force exerted by the caloric, is equal to, stronger, or weaker than, the attraction of the particles of the bodies it acts upon." And again he writes : " But if these two powers only existed, bodies would become liquid, at an indivisible degree of the thermometer, and would almost instantaneously pass, from the solid state of aggregation, to that of aeriform elasticity. Thus water, for instance, at the very instant when it ceases to be ice, would begin to boil, and would be transformed into an aeriform fluid, having its particles scattered indefinitely through the surrounding space*."

And in another place, he further states that, " without the atmospheric pressure we should not have any proper aeriform fluids ; because, the moment the force of attraction is overcome by the repulsive power of the caloric, the particles of bodies would separate themselves indefinitely, having nothing to give limits to their expansion ; unless their own gravity might collect them together, so as to form an atmosphere†."

It is only a want of due reflection on the laws of the two powers, that could have permitted the first of these passages to exist in the work of such an author. How could the attraction in a solid be greater than the repulsion, without bringing the atoms together ? That they are not in contact, he himself has proved‡. That the other statements

* Elements of Chemistry, (translated by Kerr,) p. 55.

† Elements, p. 56.

‡ Elements, p. 50.

might be true, it is evidently necessary, that repulsion be supposed to vary in the same, or a less, inverse ratio of the distance, than the attraction; either of which has been above proved impossible.

Another author of great merit appears to have written with the same impression. Mr. Dalton argued against Berthollet, that if the mixture of gases depended on an attraction exerted between them, they ought to enter into perfect combination*. This is a just objection, if repulsion be supposed to vary in the same, or a less, inverse ratio of the distance, than the attraction. And neither Berthollet, nor Dr. Murray, had shewn, that either of these suppositions is impossible; nor did they answer this objection of Mr. Dalton's as if they were aware, that the two forces could not vary in the same ratio.

Again, in explaining the nature of mixed gases, Mr. Dalton (as has been already observed) considered the attraction, and force of repulsion, between the atoms of the fluids so nearly equal, that neither force affected the mixture at all†. But then it is necessary to suppose (to the end that neither may affect the mixture of the gases) in addition to the two forces being equal, that they should also *vary in the same ratio.*

For, did they not, one of these forces beyond, or within a certain point, becoming the greater of the two, *must* operate‡.

It would be easy to shew, by quotations from all authors, that none have hitherto pursued the inquiry spoken of above; but it is sufficient to have proved this fact, from the writings of two of the ablest philosophers.

After having maturely considered the various doctrines, and theories, which are taught in the statics of chemistry; I became persuaded, that several of them were far from satisfactory; among them in particular, the doctrines, upon which I have been remarking. And while endeavouring to investigate the cause of their insufficiency, an explanation presented itself to me, which appeared free from all the difficulties, and objections, to which former theories are liable; and which will account for the permanency of all states, and combinations of bodies; namely,—

That the force of repulsion, with which heat endows atoms, varies in a greater inverse ratio of the distance than their attraction.

* Manchester Memoirs, vol. v. part 2.

† New System of Chemical Philosophy, p. 162.

‡ Vide Repulsion varying in a less ratio than attraction, and also the following law.

Let us apply this law,

First.—*To the constitution of solids.*

Let there be a liquid between the atoms of which, owing to a loss of heat, the attraction has become so far superior to the repulsion, as to bring them to that distance, at which solidity naturally subsists. And, since the attraction may be conceived to vary as the inverse square of the distance, and repulsion varies in a higher inverse ratio, let this ratio be the inverse cube of the distance, and let the atoms of the liquid be supposed to have been at any distance 4 from each other, and let the following diagram represent the opponent forces operating between any two atoms, A and B, at different distances.

Distances.	1	2	3	4	5	6
Attraction,	576	144	64	36	23	&c.
A*	.	*B	*B	.	.	.
Repulsion,	1728	216	64	27	13.8	&c.*

Here it is plain, since between the two atoms at distance 4 from each other, the attraction is 36, but the repulsion only 27, that these atoms must approach, and will come to distance 3, where both forces are equal, each being 64. The atoms of the body, which is now a solid, cannot come nearer; as at any distance within this, there is an effective repulsion operating, which must keep them at this distance, unless, by abstracting or adding more heat, the point of equilibrium is transferred to a smaller, or greater distance. Thus will be constituted a true mechanical stable equilibrium, and thus the nature of solids, and their contraction, and expansion, are at once explained.

Secondly.—*To the constitution of liquids.*

A true explanation of the constitution of liquids, which has hitherto never been clearly given, appears to be afforded by this doctrine.

In applying this law to the constitution of liquids, a third power must be taken into consideration, namely, the pressure of the atmosphere.

Let it be supposed, that these forces have brought the atoms of a gaseous fluid into the liquid state; and let the following represent all the forces operating upon any two atoms, A and B, of the liquid at various distances†.

* It is evident that these series are not supposed to represent the real forces, but are merely intended to illustrate the doctrine more clearly. The diagram represents the forces acting from one atom only, the relative power being the same, as if the forces of both atoms had been represented.

† Lest when a vapor is passing to the liquid state, any one should attribute the cause solely to atmospheric pressure overpowering the expansive force of the vapor, I may instance the condensation of hygrometric vapor in the air, on a fall

Distances.	1	2	3	4	5	6	7
Pres. of the air,	1	4	9	16	25	36	49
Attraction,	1024	256	113.7	64	40.9	28.4	20.8
A*	.		.	B*	*	.	.
Repulsion,	5120	640	189.6	80	40.9	23 7	14.8*

Here it is manifest, that both the mutual attraction of the atoms, and the pressure of the air, are tending to compress the fluid.

If the former force only operated, the atoms would be at distance 5 from each other; as there the attraction and repulsion would balance each other, and constitute a stable equilibrium. But since the latter force (pressure), operates on the liquid, the atoms are brought nearer to each other, to distance 4 *(e. g)* where the attraction and pressure, amounting together, to a force $(16+64=)80$, are balanced by the repulsive force, which at that distance is also 80. The point of stable equilibrium is thus removed to a smaller distance, where, as long as the same forces operate on the atoms, they can neither approach nor recede of themselves. Again as, in a liquid, the atoms are pressed *within* the distance, at which the attraction alone balances the repulsion, by a force (the pressure of the air), the effect of which is merely to keep the liquid within a certain bulk, it is manifest, that this *external* force does not operate towards keeping any two atoms in particular near to each other. Hence the atoms may move on each other, as long as others supply their place. And thus the peculiar character of the liquid state may be explained.

The remarkable property of a liquid, of collecting itself into drops under certain circumstances, may also be readily explained by this law.

The pressure of the air can have no more effect in forming liquids into spherical drops, than into drops of any other form. The only force, which can effect this, is the attraction of the atoms, which, as in the diagram, though weaker than the repulsion between the neighbouring atoms A and B, must become the more powerful force between any, but neighbouring atoms; and being the more powerful

of temperature. Atmospheric pressure can only act on this vapor (whose atoms are perfectly intermingled with its own) so far as it is endeavouring to expand the air, and can only increase the density of the vapor, until the elasticity of the atmosphere itself prevents its own atoms from approaching nearer to each other, or, in other words, until the vapor is of the same density as the natural density of the air; the force therefore, which in this case reduces the *vapor* into a *liquid,* must be an effective attraction, and in part the gravity of the vapor.

* The first of these forces, the pressure of the air, varies as the square of the distance of the atoms. The second, the attraction, varies inversely as the square of their distance. The third, the repulsion, varies in any higher inverse ratio of the distance, *e. g.* inversely as the cube of the distance.

force, it collects several atoms into a drop, under favorable circumstances.

The gradual expansions and contractions of liquids can also be explained by this law. The distance of the equilibrium is gradually increased, or lessened, by an addition, or abstraction of heat; and whatever difference should exist between the forces at any one distance, a stable equilibrium would be formed at some other, where the atoms would be fixed. The doctrine then, that the force of repulsion from heat, varies in a greater inverse ratio of the distance, than the attraction, affords a happy explanation of the nature and constitution of liquids, and also of their gradual contractions and expansions, with variations of temperature.

Thirdly.—*To the constitution of simple gaseous fluids.*

It has been above remarked, that the pressure of the atmosphere is the chief force opposing the repulsion, in a gaseous fluid. But it has also been shewn, under a former head*, that atoms in a gaseous state attract each other. And this force, though certainly much inferior to the pressure, must aid the operation of the latter.

Let all the forces operating from any atom A towards any other atom B, of a simple gas be represented by the following diagram:

Dis.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Pr.	1	4	9	16	25	36	49	64	81	100	121	144	169	196	225	256	289	324	361	400
Att.	648	162	72	40,5	26	18	13,4	10,1	8	6,4	5,3	4,4	3,8	3,3	2,8	2,52	2,24	2	1,8	1,62
A*	.	.	.	.	.	B*	.	.	.	.	.	.	.	.	.	.	.	B*	.	.
Rep.	11664	1458	432	182	93,3	54	34	28,8	16	11,6	9,64	6,7	5,3	4,2	3,4	2,9	2,37	2	1,7	1,45

In this case, the atoms of the gaseous fluid will be stationary at distance 6, where the repulsion, being 54, is equal to the united attraction and pressure, (18+36) which are also 54. On removing the atmospheric pressure there being a powerful effective repulsion, the atoms must separate greatly, unto that point at which, from the repulsion varying in a higher ratio than the attraction, a stable equilibrium is established. In the above instance, this is at distance 18, where the attraction and repulsion being each 2, the gaseous fluid will expand no further, although all external pressure is removed.

To this, I am aware, it may be objected, that the air in the receiver of an air pump expands without limit, as long as a portion is removed, and, therefore, that the attraction cannot be equal to the repulsive force at any distance of the atoms.

This however it will be easy to shew is no objection. In proportion as the air expands in the receiver, so does its tendency to part with

* The distance to which attraction is exerted.

heat grow less, (i. e. it falls in temperature,) and hence it rapidly receives heat forced into it from the vessel and external air. The truth of this is evident from the fact, that, during the experiment, the rarefied air at first falls in temperature, but afterwards rises to the same temperature as the external air; and if the exhaustion be again continued, the air again expands, falls in temperature, and therefore again receives heat; and, as long as heat is forced into it, so long must it expand, and the point of stable equilibrium be removed to a greater distance. Were it possible to procure a receiver impermeable by heat, there is every reason to believe, that the expansion of the contained air would terminate after several increments of volume; for it cannot be supposed, that, on the removal of pressure, a gaseous fluid would expand without limit, unless the repulsive force, operating between its atoms, be considered to vary either in the same or in a less inverse ratio of the distance, than their attraction; and since it has been already shewn, that either of these cannot be a law of the repulsion in bodies, in any degree of combination, or in any other state, analogy will show, that neither of them can be a law of the repulsion of atoms in the gaseous state.

Another objection which may be presented, is, the *apparent* fact, that the effective repulsion in gases, varies inversely as the distance of the atoms; for, according to the doctrine which I have laid down, since the actual repulsive force is considered as varying in a higher inverse ratio of the distance than the attraction, and since the attraction is supposed to vary as the inverse square of the distance, the effective* repulsion ought to vary in a higher inverse ratio of the distance than the inverse square; and not therefore only inversely as the distance, as it appears to do. To this I may answer, that, as I have before remarked, an ingress of heat takes place, on removing pressure from the air, and an egress on increasing the compressing force. This reception of heat on the one hand, and loss of heat on the other, must cause the effective repulsion apparently to vary in a much lower inverse ratio of the distance, than it would, did the air always possess the same quantity of heat; and from this cause Mr. Boyle's experiments, and the doctrine I have laid down, contain nothing contradictory.

In like manner, in the case of a body gravitating towards a planet, the force varies inversely as the square of the distance from the centre. But, by varying the quantity of matter in the planet, in some

* The excess of the repulsion, over the attraction; the only force which, in a gaseous fluid, admits of measurement.

direct ratio of the distance, its attraction might be made to vary in any less ratio than the inverse square.

The reader will perceive, that the ratio of the attraction of the planet, in the one case, and the doctrine I have laid down, of the ratio of the repulsion in the other, were both disturbed by the absolute forces varying. In the former case, by the quantity of matter in the planet, in the latter by the quantity of heat in the air subjected to experiment being constantly changed.

And moreover, I may observe, it would appear from later experiments than Mr. Boyle's, as is well known, that the elasticity of the air varies in a somewhat greater ratio, than the density, and therefore that the effective repulsion varies in a higher inverse ratio, than inversely as the distance.

The following quotation from an author in Dr. Rees's Cyclopædia* will strongly corroborate the views I have taken of the constitution of gases. After some former remarks he observes : " Thus also in high degrees of rarefaction, the elasticity is decreased rather more than in exact proportion to the weight or density of the air ; whence it may be concluded, that there is a *limit* to its rarefaction, or expansion, so that it *cannot be expanded to infinity.*"

This observation, which is founded on actual experiments of philosophers (and which appears to me a just one) is exactly conformable to the doctrine I have laid down. This doctrine therefore (that the force of repulsion, from heat, varies in a greater inverse ratio of the distance than the attraction) which must be admitted to explain the situation of of atoms, in other states of bodies also, I think, elucidates clearly the nature of gaseous elasticity.

Fourthly.—*To the solution of solids in liquids.*

In applying this law to the solution of a solid in a liquid, it is proper to take into consideration all the forces, which can operate either for, or against the combination.

In a saline, or any other solution, of a solid in a liquid, there are at least, five forces, which must greatly affect the solution. Two of these operate in favor of the solution, and three against it ; and in proportion as the former forces exceed the latter so will the combination be the more intimate.

When a salt is immersed in water, it is true, that the cohesion and greater specific gravity of the salt are opposed to the affinity between the water and salt, but these (which as far as I am aware are alone

* Article Air.

mentioned by Berthollet and Dr. Murray) are not the only forces which affect the solution. There are two others, which perhaps have quite as much influence on the extent of the combination ; namely, the repulsive force, operating between the atoms of the salt, and the repulsive force between these atoms, and those of water*. It is this last force, which prevents the most perfect combination from ensuing. It has however, been shewn, under a former head, that if this force, (viz. the repulsive force operating between the solid and liquid) varied in the same ratio as their attraction, it certainly could not prevent the atoms of the former, from being brought into absolute contact, with those of the latter.

But, admitting this repulsive force to vary in a higher inverse ratio of the distance, than the attraction, the nature of the solution may be clearly explained in the following manner.

It is plain, that the forces opposed to the solution, are the cohesion, the greater specific gravity of the solid, and that repulsive force which must operate between its atoms, and those of the water. That the forces favoring the solution, are the repulsive force operating between the atoms of the salt itself, and their affinity for those of the water. If when the salt is immersed in the water, the two latter forces united, are more powerful than the three former united, the water must begin to act on the salt. As the atoms of salt separate from each other, the repulsive force operating between them, which is one of the forces favoring the solution, at last loses its effect, owing to its varying in a greater inverse ratio of the distance than the cohesive attraction of the salt, and therefore becoming weaker than the cohesive attraction.

Again, as the atoms of salt and water approach each other, the repulsive force operating between these two bodies, though formerly much inferior to their affinity, owing to its varying in a higher ratio, becomes at last, at a certain point, equal to the affinity. And could the atoms of the salt be brought still nearer to those of the water, the repulsion for the same reason would grow superior to the affinity. It is manifest then, as the atoms of salt and water cannot approach nearer to each other than the point, at which the two powers are equal, that the atoms must rest at this distance from each other : for there the two forces form a stable equilibrium.

And, since the atoms of liquids are endowed with greater atmospheres of heat, than those of solids, this superior repulsive force in them may

* The repulsive force and attraction operating between the atoms of the water themselves need not be mentioned : as the doctrine may be explained without taking them into consideration.

cause the point of stable equilibrium, between the atoms of the solid and the fluid, to exist at a greater distance, than between the atoms of two solids when in combination, and hence the latter combinations are generally much more intimate than the former.

The solution of solids in liquids and the weak resulting combination, are therefore satisfactorily explained by this doctrine ; which considers the force of repulsion from heat as varying in a greater inverse ratio than the attraction.

Fifthly.—*To the solution of liquids in gases and in the atmosphere.*

Under a former head, I have endeavoured to prove, that the hygrometric vapor of the atmosphere must exist in that state, partly by its own elasticity, and partly by an attraction exerted on it by the air. But it was also proved, that if the repulsion of atoms varies in the same ratio, as the ratio of attraction, the atoms of water would come into actual contact with those of the air ; which cannot be the case, as hygrometric vapor is in the very weakest state of combination with the air. The solution of vapors in gases, without an intimate combination ensuing, may however, I think, be readily explained by the present doctrine.

Let a liquid A be placed under a column of dry air B, which is pressing on it with the usual force of the atmosphere. It is plain that the layer of air nearest the liquid must press on the latter with the whole force of the atmosphere which it supports. But the particles of air are far more distant from each other than those of water ; probably ten times as far. Let us suppose this to be their relative distance. Every tenth particle only of the liquid will be pressed on perpendicularly by the lower stratum of air ; and the condensation of the circumambient heat of this stratum will be so much greater perpendicularly under each particle of air, than obliquely between them, that it will re-act more upon the water directly under those particles, and press it into dimples, as in the figure. The ridges between these dimples will be pressed on laterally by the elastic medium of each aerial particle, but with little force downwards.

All the aerial particles above this lowest stratum must be at a greater distance from those of the water, than the point at which the forces operating between them and the water, are equal. And, being at a greater distance than this point, they must attract the water with more force than they repel it, according to the present postulate. If then the united *effective* attractions of all atoms of air above the lowest stratum, together with the tendency to expand in the water itself, be superior to the gravity of the atoms of water situated in the several ridges, the

latter must rise into vapor, and so also must those which supply their place. And the atoms of water, as they rise, will necessarily become intermingled with those of the air, and will be detained among them by their attraction for them. But, since *the repulsion varies in a greater inverse ratio of the distance than the attraction* it will form a stable equilibrium with it, at a certain point, within which it will prevent the atoms of water from approaching those of the air ; that is, prevent an intimate combination from ensuing.

Thus is explained the fact, that an attraction between the air and water may favor the transition of the latter into vapor, and yet not bring the atoms of water into intimate combination with those of the air, a fact, which I do not think can be explained by any other doctrine.

Sixthly.—*To the constitution of mixed gases.*

The minute investigation into the various theories proposed to explain the nature of a gaseous mixture, which I have endeavoured to pursue, has shewn, that each of them is liable to one or more insuperable objections.

It appears to me that *this* phenomenon also, may be explained by the application of the present doctrine.

Having first stated the theorem, I shall endeavour to demonstrate it.

If a cylindrical vessel, of any given length, be filled with hydrogen gas, and inverted (so as to fit closely) over a similar vessel filled with carbonic acid gas ; part of the former gas, although of far less specific gravity than the latter, will descend, and part of the latter will ascend, until the atoms of hydrogen gas, are perfectly mixed with those of carbonic acid gas, and, when mixed, they will not enter into combination.

This may be demonstrated in the following manner.

Since the repulsive force, operating from the atoms of the one gas towards those of the other, varies in a greater inverse ratio of the distance, than their attraction, it must form with this force, at a certain point, a stable equilibrium. Since when the hydrogen gas is placed on the carbonic acid gas, the lowermost atoms, of the former, press upon the upper stratum, of the latter, these contiguous strata, of the two gases, must be brought within the point of equilibrium, between their attraction and mutual elasticity; and must therefore have an effective repulsion for each other.

But, excepting the contiguous strata, all the atoms of the one fluid must be farther from those of the other, than the point of stable equilibrium, and must therefore, exert an effective attraction for them.

If then their mutual effective attraction be superior to their difference of gravity, atoms of hydrogen gas must descend, and of carbonic acid ascend until the mixture is complete. When mixed however, no atom of the former can approach nearer to one of the latter gas, than the distance at which the forces, operating between them, form a stable equilibrium : for within that distance an effective *repulsion* exists. This distance, owing to the great quantity of heat round gaseous atoms, will be so considerable, that the atoms of the two fluids cannot produce on each other those changes, attendant on combination. From which, the gases must be considered, as merely having their atoms detained approximate to each other, by their mutual attraction.

In like manner, may the constitution of the *atmosphere* be elucidated ;—its consisting of gases in a state of mixture, though of different specific gravities, and yet not entering into intimate combination with each other.

Conclusion.

The inquiry into the law of the repulsive force, with which heat endows atoms, namely, of that compound repulsion resulting from the opposed action of the two ultimate powers of heat, themselves, which it has been my endeavour to pursue with such minuteness, as the length of this essay would permit, has, I trust shewn, that this power must vary in a higher inverse ratio of the distance, than the attraction.

By way of illustration, I have imagined this ratio to be the inverse cube, that of attraction being the inverse square of the distance ; but I would by no means be understood as intending to enforce this as the actual ratio. Since (as has been above remarked) the actual ratio of this compound repulsion, it is probable, differs in bodies according to the force of their attraction for the particles of heat, it will perhaps never be possible to ascertain it exactly in any individual case. But the limit, which has been laid down, is of the highest importance, since (as I trust) I have deduced from it a simple doctrine, which accounts for the stable residence of atoms at various distances from each other, constituting in nature, solids and liquids, combinations of solids with liquids, liquids with aerial fluids, and mixtures of aerial fluids with each other ; and without which none of these phenomena can be accounted for, but they may even be *demonstrated impossible.*

IV.—*Iron Suspension Bridge over the Beosi River, near Ságar, Central India. Pl.* XVI.

We take peculiar pleasure in bringing to the notice of our readers the completion of this work of art, because it has been constructed entirely out of the resources of the country, and being the first attempt at such an adaptation of native material and native workmanship, more than ordinary credit is due to the skilful engineer who planned and executed it, and who moreover, from his long residence in India, could have acquired only a theoretical acquaintance with the system of suspension bridges introduced within these few years, and now so rapidly spreading, in Europe.

The bridge was erected at the suggestion of T. H. Maddock, Esq. agent to the Governor General in the Ságar and Nerbada territories, upon the plans and under the sole superintendence of Major Duncan Presgrave, mint and assaymaster at Ságar.

Engineers in Europe, accustomed to find every thing provided to their wants, can have little idea of the personal labour which devolves upon their brethren of the craft in this country, where to the duties of architect and draughtsman are not only added those of builder and overseer, but the whole of the subordinate trades of the brick-maker, mason, carpenter, and iron-manufacturer ; in a climate too where a trifling exertion produces exhaustion ; and incautious exposure, fever or death : and where the tools must be made and the hands that employ them instructed *ab initio*. We will not say that the native mistrees and labourers are not capable of learning or of working well, especially in upper Hindustán ; the bridge before us is a sufficient refutation of that common and *indolent* remark : but all will agree that a peculiar talent is requisite to manage, instruct, and drill them ; and this faculty is possessed by Major Presgrave in an extraordinary degree. The secret of his influence may be easily traced ;—he is a workman himself : he wields the hammer ; makes and works the lathe ; surveys the ground ; searches the mines ; smelts the ore ; and has all the skill of contriving with the simplest means*, for which the people of this country are themselves so conspicuous.

The Ságar bridge may indeed be called an experiment to try the resources of the country ;—to see whether the iron could be manufactured into bars of a quality fit for bridges ;—and whether these bridges could be made by native workmen who had never wrought or

* As an illustration of this remark, we refer to the description of the rollers on which the chains rest.

even seen iron of the dimensions required. The question has been satisfactorily answered ; and even in point of economy, notwithstanding the numberless extra expences incident to a first undertaking, and the distance, eleven miles, of the work from the yard at Ságar, the bridge has been pronounced cheaper than those in Calcutta made with English materials : while of its design and execution no higher encomium can be given than the assurance of the visiting engineer, Major Irvine, that he had seen nothing superior to it in Europe. The Governor General is stated to have expressed equal satisfaction after inspection, and only to have regretted that so noble a bridge should be wasted upon so remote a locality !

We have with permission taken a reduced copy of the elevation and plan, lithographed by M. Tassin, to accompany a private Memoir of the Beosi bridge. The latter authentic source supplies us with the following particulars of the work.

The foundation was laid in April, 1828, and the roadway opened to the public in June, 1830.

The iron of which it is composed is entirely the produce of the Ságar district. When the bridge was projected, it was still in the state of ore in the mines, whence it was extracted, smelted and made into irregular small lumps, in the common native fashion. The working of these crude impure masses into good bars of the requisite dimensions was a matter of very great labour and difficulty.

The bridge is 200 feet in span between the points of suspension.

The piers, resting on the solid rock, six feet under the low level of of the river, are 42 feet high to the roadway ; being elevated two feet above the ordinary surface of the country : they have a base of 32 feet by $22\frac{1}{2}$, decreasing upwards in front one in five, and on the sides one in eight feet ; which gives on the road a superficies of 21 by 14 feet for each pier. On the sides are wing walls or abutments, running back into the bank 26 feet.

The pillars, or rather arches, of suspension have a base of 21 by 12 feet, admitting a roadway of 9 feet broad. The arches are 15 feet high, and are faced with accurately wrought stone. The points of suspension are elevated 22 feet $4\frac{1}{2}$ inches from the road : the pillars have a total height of 33 feet, and the whole masonry from the rock, 68 feet. The piers and abutments contain 82,488 cubic feet of masonry ; the arched standards and bridge parapets, 8900 : in all 91,388 cubic feet.

The platform measures 200 feet in length by 12 feet broad, and is calculated to weigh, with the chains, $52\frac{3}{4}$ tons. Supposing the bridge crowded with men, at 69 lbs. per superficial foot all over the platform,

the whole weight would be 120 tons, whence it is calculated that the tension to be sustained at each point of suspension would be 85.632 tons.

The suspending chains are 12 in number, arranged in pairs, three pair on either side, two feet above one another. They pass over rollers one foot in diameter, and are securely moored in masonry 16 feet below the surface of the road. The back chains are 101 feet long, rising at an angle of 27 degrees. The angle of the catenarian at the roller is 16° with the horizon : the versed sine at the centre of the curve is 14 feet 3 inches.

The twelve main chains are of round bar iron, one and half inch diameter, bolted together in pairs. They are from 15 to 15.5 feet long, and so arranged that the vertical rods may fall from the joints of each chain alternately in parallel lines five feet apart. The descending chains are square bars measuring $1\frac{1}{3}$ inch on the side: their lower ends pass through 24 conically wrought stones, below which they are capped and keyed. (Figs. 1 and 2.)

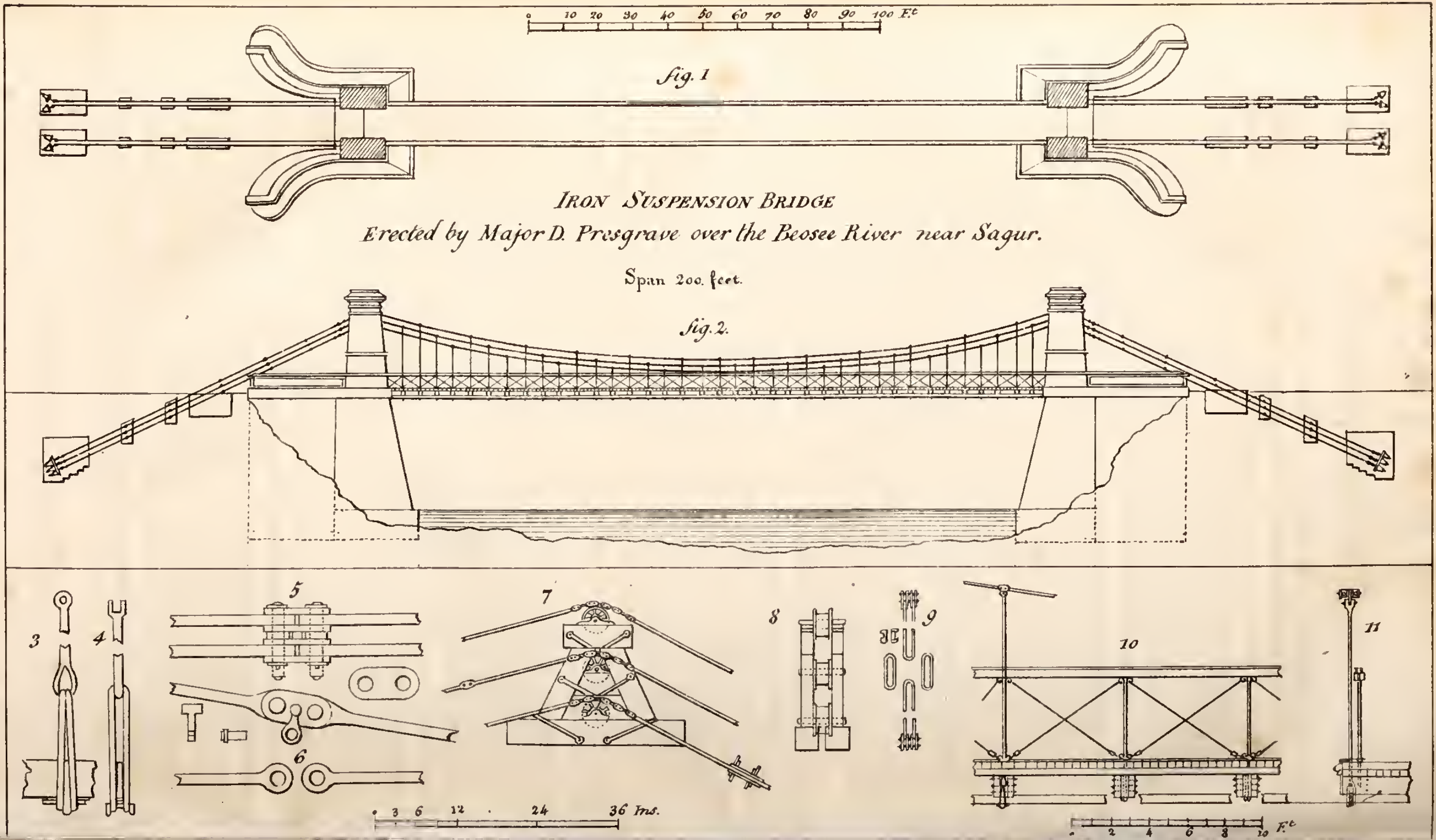
The connecting links of the chains, and indeed all the bolt holes in the bars, and the drops, are bored out of the solid iron, and broached to fit the bolts accurately. (Figs. 5, 6.) None were punched at the forge. The bolts are $1\frac{1}{2}$ inch in diameter, and are secured by rings, or washers and keys. Two adjusting links with iron wedges are fitted to each chain, close to the masonry landward, to regulate its curve and dip. (Figs. 7, 9.)

The method of constructing the rollers is thus described in the memoir :

"The iron rollers 12 in number weigh about one cwt. each. They are not solid, but are composed each of about 28 separate pieces of wrought iron, viz. a centre tube or box for the axle over which thick rings are driven ; and an exterior drum between which and the inner ringed tube, flattened bars, as spokes, are driven. The centres were broached out clean and true, and cylindrical axles 3.1 inch in diameter were turned to fit ; the ends of these axles rest on broad thick iron bearings mounted on very strong and solid frames of timber well bolted, clamped and blocked together, covered with pitch cement and secured in the masonry of the pillars." (Figs 7, 8.)

The platform was made in a different mode from those of our Calcutta bridges, as will be understood by the following explanation:

"From the short links set between the centre plates of the shackles (of the main chains), are suspended alternately from each tier, 74 vertical round rods one inch in diameter connected to a short link (Fig. 6) by a one-inch round bolt passing through it and the socket at the upper end of the bar ; at their lower ends the rods have eyes, through which doubled loops of iron pass (3, 4) for sustaining the flat bars or girders, set on their edges and proceeding from one end to the other on both sides of the bridge.



IRON SUSPENSION BRIDGE

Erected by Major D. Presgrave over the Beosee River near Sagur.

Span 200. feet.

" The flat bars, four inches broad by $\frac{3}{4}$ inch thick and in lengths of fifteen feet, are joined together at their ends by nicely turned bolts passing through bored holes two inches in diameter ; they are adjusted in their height by double wedges, resting on holders that connect the sides of the loops together. The girders are also adjustable in their lengths, the bars that enter tbe masonry have their ends made broader than the rest of the bars, in which are long openings 2 inches broad to receive wedges. (Fig. 10, 11.)

" Eight timbers in an upright position are set in the masonry of the pillars, having upright grooves or spaces cut through them, and faced with thick plates of iron ; througb two of these beams each end bar passes, and may be wedged on either side of the timber towards the land as occasion may require ; thus is the whole length of girder drawn more or less to either end of the bridge, and also rendered exceedingly tight and steady. The grooves in the timbers towards the river, being about four inches longer than the breadth of the bars, permit them to adapt themselves to their proper directions when drawn lengthwise by the wedges acting against the landward beams ; by these means the bars have sufficient play to adapt themselves to the motion of the platform, and all jerks at the pillars are obviated.

" Thirty-seven double joists twelve feet long are, (having their ends notched below for the purpose,) laid on the girders : their centres five feet apart correspond exactly with the vertical rods that pass througb them ; the joists are composed each of two cheeks a foot in depth and three inches thick, separated at intervals by four blocks of wood of the same heigbt and tbickness ; all firmly put together with bolts, screws and nuts : two cleats are nailed to each end of the joist on their under sides, whose ends fit flat against the girder and keep all steady.

" Planks sixteen feet in length running longitudinally, each plank stretching rove three spaces, and regularly disposed as to their joints, are spiked down on the joists : in a direction across these and upon them other planks are spiked down, their lengths being the same as the breath of the platform. The planks are all imbedded in a composition of resin boiled in linseed oil, which in laying on is mixed with ashes. Tbe lower planks are three, and the upper ones two and half inches thick : they are only six inches broad to prevent warping, and have two strong square-headed spikes passing through them near their edges, at every crossing of the upper over the lower planks : their points are clinched below the platform, to accomplish which 16,370 spikes, weighing a ton and a half, were used ; tbus the platform has been rendered extremely strong and firm.

"The better to secure the sides of the platform and the ends of the timbers from the weather, a cornice or moulding of wood is nailed along the outside.

"The hand-rail is trussed, and consists of iron pillars or stancbions ; diagonal braces of iron ; and a stout wooden rail running from end to end of the platform : the whole put together with screws aud nuts, and adjusting screws for setting up or tightening the diagonal braces whenever required. (Fig. 10.)

"The rise in the platform is (as before stated, nine inches, but the curve of the hand-rail is only three incbes, to effect which the stanchions that support the rail are of varying lengths. The rail being four feet six inches above the platform at its connection with the masonry, but only four feet in the centre of the bridge."

The following are the weights of the chains, rods, and materials of the platform:

	Iron. Tons.	Wood. Tons.	Tons.
6 double main chains, joints and bolts..............	8.5		
74 vertical rods, with joints, bolts, &c...............	1.385		
Flat bars and bolts,..................................	1.726		
37 double joists, blocks, cleats, &c....		6.190	
Bolts, nuts, screws, stanchion plates, flat rings, &c. &c. from beams...	0.383		
Planking 1.124 cubic feet, sal wood,................		27.000	
Iron spikes, 16.370 for planking, ...	1.467		
Iron railing trussed, screws, nuts, &c............ ..	1.314		
Wood for the hand rail, 52 cubic feet,..............		1.479	
376 feet of cornice to the platform.......	——	1.531	
	14.775	36.200	50.976
Composition of resin and oil,.................... .			1.745
Total weight hung between the pillars,.............		tons.	52.720

V.—*Additional Note on the Climate of Nagpúr.* *By* J. Prinsep, *Sec. As. Soc. &c.*

In the May number of the Journal were published the results of Dr. Geddes' Meteorological Observations made in 1831-32 at Kamptí, in the neighbourhood of Nagpúr, which, as observed by the author, were in some degree deficient for the want of a barometer ; the sympiesometer which took the place of that instrument shews by the registers a constant deterioration from the increase of the column of air*, which renders its indication of comparative inutility in accurate calculations. I am now fortunately able to supply the deficiency, of barometrical data, from the copious registers kept by Dr. Wylie at Nagpúr, between the years 1820 and 1830, (with some intermissions,) of which that gentleman was so kind as to permit me to take copies ere he proceeded to Europe.

Dr. Wylie's barometer was filled by himself without boiling. A note in his diary in 1820 states, that it stood 0.235 lower that some other tube (Dr. Voysey's ?) with which it was compared. In February 1822, the tube was cleaned twice, and fresh mercury added: in May of the same year it was again cleaned. On each of these occasions, the height of the mercurial column was elevated more than a tenth of an

* This is a fault in the sympiesometer which might perhaps be remedied by making the oil-cistern higher, so that the oil should on an average stand on the same level in the two legs of the inverted syphon. In an instrument in my possession after one year, in 1822, the index point had fallen 0.3 inch below the barometer ; in 1823, 0.5 inch ; in 1825, 0.8 ; and now, in 1833, I find it 1.38 inches : Dr. Geddes, according to his register, must have followed the same rate of deterioration : the level in mine is now nearly even with the reservoir.

inch for the time, proving that air or moisture had previously insinuated itself into the vacuum. In November, 1824, a note occurs, at Bombay :—" add .200 to make barometer agree with one afterwards used and found to be more correct." The change of instrument was made in January, 1826 : the new tube was again cleaned and repaired in June and in November* : it broke in May, 1829, and was replaced by one standing full .200 lower. These circumstances were pointed out by Dr. Wylie, as depriving his tables of that measure of exactitude required for deducing the altitude of Nagpúr barometrically ; but with the precaution of augmenting the whole of the indications up to September, 1823, by two-tenths of an inch, and proceeding in the same manner with May—September of 1826, and with new barometer of June, 1829 ; all of which alterations are borne out by notes on the diary ; the results will be found to agree very well *inter se*, and to be fully sufficient for the determination of the annual and diurnal oscillations, which it is my object to deduce for as many points as possible on the Indian continent.

The following tables present an abstract of the monthly means deduced from Dr. Wylie's daily observations : they have been reduced to the temperature of 32° Farh.

Five months of 1820 are omitted for want of space, as the year was incomplete ; but the entries were used in the calculations of the monthly means in the tables which follow.

Table I.—*Meteorological Observations at Nagpúr, by* Dr. Wylie. *Barometer reduced to* 32° *Farh.*

	1821		1822		1823		1826	1827	1828	1829
	9 A. M.	5 P. M.	9 A. M.	5 P. M.	9 A. M.	5 P. M.	NOON.	NOON.	NOON.	NOON.
January,	28.906	28.783	28.839	28.722	29.026	28.927	28.880	....	28.867	28.807
February	29.031	.914	.866	.725	28.980	.886	.780	....	.752	.796
March,	.102	.989	.756	.642	.862	.779	....	28.759	.716	.733
April,	.038	.895	.698	.587	.763	.655	....	.666	.622	.615
May,	28.842	.729	.710	.646	.695	.610	.612	....	.562	....
June,	.695	.611	.667	.593	.682	.568	.481	.402	.427	.390
July,	.563	.492	.643	.543	.630	.514	.455	.401	.437	.458
August,	.465	.412	.646	.560	.693	.610	.507	.478	.512	.508
Sept.	.558	.472	.706	.613	.803	.680	.547	.515	.515	.556†
October,	.733	.634	.828	.724			.724	.711	.688	.675†
Nov.	.805	.760	.970	.859			.844	.811	.841	.845†
Dec.	.889	.770	29.012	.922				....	.847	.847†

† 0.200 has been added to these five months as supposed index error of a new tube then used.

* After this filling of the tube in the *damp weather* of June, we find the mercury for five months standing full two-tenths too low, confirming my remarks in a former number of the Journal. The cleaning in the dry weather of November again raised the index to the same or even a greater amount.

Table II.—*Thermometer in doors, attached to the Barometer.*

	1821		1822		1823		1826	1827	1828	1829
	9 A. M.	5 P. M.	9 A. M.	5 P. M.	9 A. M.	5 P. M.	NOON.	NOON.	NOON.	NOON.
January,	72.9	78.7	71.3	76.3	74.7	78.0	74	....	71	72
February	76.0	82.3	75.0	82.4	77.0	82.0	78	....	76	72.5
March,	81.0	84 0	82.8	88.2	80.3	84.5	....	83	81.5	83
April,	87.7	90.7	86.0	88.3	88.0	91.0	....	84	83	85.5
May,	87.8	91.0	91.5	93.2	88.8	88.6	82.5	....	84	....
June,	89.0	91.3	87.0	90.1	88.5	89.4	88.7	89	86	....
July,	81.9	84.7	83.1	84.9	84.2	86.2		85	83	81.5
August,	80.9	83.5	82.6	84.0	82.9	84.3		81	83	81
Sept.	81.0	83.4	82.0	83.2	83.0	83.7		82	82	82
October,	77.7	83.5	83.0	86.0	....	....		83.5	81	82
Nov.	75 5	79.9	76.8	81.3	....	....		76	76	75.5
Dec.	66.7	74.0	72.8	76.6	....	....		73	71	72.5
Means	79.8	84.0	81.1	84.5			80.9		79.8	78.7

Table III.—*Fall of Rain at Nagpúr, registered by* Dr. Wylie.

Month.	(Lloyd) 1814-15	1826	1827	1828	1829	1830	1831	1832
January,	..	2.30	0.40	0.19	..	..	..	..
February,	..	..	0.50	1.21	0.76	..	..	2.98
March,	..	..	3.84	0.71	2.49	1.57	..	..
April,	..	..	1.01	0.06	0.06	0.68	..	..
May,	..	1.10	0.21	1.55	..	1.35	..	..
June,	0.23	22.23	6.25	8.37	8.07	8.54	13.78	8.01
July,	7.08	12.00	14.93	9.33	15.94	7.10	7 22	14.49
August,	14.72	18.50	7.51	9.07	7.89	7.00	14.58	3.46
September,	7.36	8.13	16.32	9.40	6.32	4.78	11.98	7.77
October,	2.97	0.04	0.00	6.46	8.22	1.98	7.24	...
November,	0.45	1.31	2.89	0.26	..	..	2.27	..
December,	..	..	0.13	..	0.50	..	8.24	..
Annual, Total,	32.81	65.61	53.99	46.61	50.25	33.00	65.31	37.14
In the Monsoon,	32.36	62.00	45.22	44.18	46.44	30.75	54.80	33.73

Average of eight years, ... 48.10 inches.

From these data we may proceed to calculate the annual and diurnal ranges, according to the form adopted in my former tables in the first volume of this Journal, page 23. The Latitude of Nagpúr is about 21° 10′ N. and the Longitude 79° 15′ E., the Barometer therefore should have a smaller rise and fall, during the year, than that of Calcutta, but greater than that of Madras, and so it turns out. There should also be a corresponding modification in the annual range of temperature, and in the diurnal change of heat and pressure : but I must leave any general deductions until I have accumulated other tables, to place in comparison with those already collected. A very accurate annual series has been kept at Cuttack by Captain B. Blake, which I trust will shortly appear in the Journal.

Average Range of the Barometer at Nagpúr, reduced to 32° Farh.

Month.	For the years 1820-23. 9 A. M.	5 P. M.	Mean.	For the years 1826 to 1829, at about 1 P. M.	Monthly difference from annual mean.	Mean Diurnal Barometric Tide, 1820-23.	Prevailing winds.
	inch.	inch.	inch.	inch.	inch.	inch.	
January, ..	28.926	.810	28.868	28.851	+.162	.116	E.
February, ..	.959	.845	.902	.776	+.142	.114	var.
March, ..	.906	.803	.854	.736	+.098	.103	var.
April, ...	.833	.712	.772	.634	+.008	.121	Wy.
May, ...	.749	.662	.705	.587	—.051	.077	W.
June, ...	.637	.539	.588	.425	—.191	.098	W.
July, ...	.576	.486	.531	.438	—.213	.090	W.
August, ..	.587	.507	.547	.501	—.173	.080	W.
September,	.674	.575	.625	.533	—.118	.099	W.
October, ..	.796	.683	.739	.699	+.022	.113	Ny.
November,.	.887	.809	.848	.835	+.144	.078	NE.
December,.	.950	.846	.898	.847	+.175	.104	var.
Means,....	28.790	28.689	28.739	28.657	Range .388	.100	

In lieu of taking the thermometric means from Dr. Wylie's Tables, which are only entered for the hours at which the barometer was registered, the following extracts from a Journal kept by Captain Lloyd, for which also we are indebted to Dr. Wylie, will better serve to furnish the range of the daily temperature.

Thermometric Range at Nagpúr, by Captain Lloyd.

Month.	1809. max.	min.	mean.	1814-15. max.	min.	mean.	Monthly difference from annual mean.	Mean diurnal range.
	°	°	°	°	°	°	°	°
January, ..	78	69	68	83,8	57,5	71,0	—11,4	17,1
February, ..	87	72	75	87,1	63,3	73,9	— 6,5	19,4
March, ..	98	64	83	98,9	69,0	85,2	+ 3,1	31,9
April,.. ..	100	77	89	102,5	81,3	93,0	+10,5	21,6
May, ...	101	79	90	104,4	91,6	98,4	+13,3	18,4
June, ...	91	76	84	103,6	85,6	90,3	+ 6,2	16,0
July, ...	88	74	79	86,9	78,4	82,5	— 0,2	10,8
August, ..	86	70	79	88,9	77,3	82,7	— 0,1	13,8
September,	85	75	79	91,9	78,2	84,3	+ 0,7	11,8
October, ..	88	64	79	89,3	74,4	83,1	+ 0,1	19,4
November,.	86	54	73	87,8	60,9	75,3	— 6,8	24,4
December,.	85	57	72	84,9	60,6	72,6	— 8,6	26,1
Mean, ...	89.4	69.3	79.2	92,5	73,5	82,7	Range 24,6	19,2

The constant difference between the numbers of the two years leads me to attribute it to an index error of one of the thermometers. Probably the second instrument stands too high, for the other more nearly agrees with those of Drs. Wylie and Geddes. A want of prior comparison with a standard instrument thus often destroys confidence and robs of half its value the labour of years. Such an error however does not

interfere with the results derived from this table, namely, the monthly and diurnal range:—it only affects the mean annual temperature, which, with all the data before us, cannot positively be determined, although the numerous observations of different hours and with different instruments may neutralize many irregularities: thus we have the mean annual temperature,

At Sunrise, in the open air..	69,5	from Dr. Geddes' Tables (page 241.)
Minimum temperature, ...	69,3	by Captain Lloyd.
At nine A. M. in the house,..	80,5	by Dr. Wylie.
At noon ditto, ...	80,3	(tatty used in the hot months?)
At two P. M. ditto, ...	81,1	by Dr. Geddes.
Maximum temperature, ...	89,4	by Captain Lloyd.
At five P. M. ditto, ...	84,2	by Dr. Wylie.
At eight P. M. ditto,........	80,2	by Dr. Geddes.
Mean of maxima and manima,	$\left\{\begin{matrix}79,2\\82,7\end{matrix}\right\}$	by Captain Lloyd.

From the mean of the maxima and minima, and from the pair of observations at 9 A. M. and 8 P. M., it may be assumed with tolerable confidence that the mean temperature of Nagpúr does not differ much from 80° Farh. which is nearly two degrees higher than that of Calcutta, and $1\frac{1}{2}$ lower than that of Madras.

VI.—*Proceedings of the Asiatic Society.*

Wednesday Evening, 30th October, 1833.

The Honorable Sir Charles Theophilus Metcalfe, Bt. V. P. in the Chair.

The Proceedings of the last meeting were read.

Read, a letter from Colonel Casement, Military Secretary, stating that the Government will have much pleasure in transmitting to the Honorable the Court of Directors the Report on the Experimental Boring, and in recommending a compliance with the Society's application for such a supply of apparatus as will enable them to continue it in an efficient manner.

Read, a letter from G. A. Bushby, Esq. Sec. Gen. Dep. communicating the permission of Government for the dispatch of 100 copies of the 18th volume of the Researches by the first ships of the season, free of charge for freight.

Read, a letter from W. Twining, Esq. Secretary to the Medical and Physical Society, expressing their regret at being unable to pay a monthly contribution for the use of the rooms occupied by their Library and Museum, and repeating the acknowledgment of the President and Members for the liberality which has afforded them that accommodation.

Read, a letter from J. C. Morris, Esq. Secretary Mad. Lit. Soc. requesting the loan of a volume of the Mackenzie MS. Translations of Inscriptions in the South of India. *Resolved,* that the request be immediately complied with.

Read, a letter from the Rev. Dr. Burrow, forwarding the printed prospectus of a plan for an expedition into Central Africa, and requesting the encouragement and assistance of the Physical Class of the As. Soc.

Resolved, that the funds of the Society are not in a state to allow a contribution towards the objects of the African expedition, but that the aid of individuals be invited by circulation of the prospectus amongst the members*.

Library.

The following books were presented:

Third part of the sixteenth volume of the Transactions of the Linnæan Society, together with a list of its members, for 1832—*by the Society.*

Transactions of the American Philosophical Society, part 2nd, vol. 4th, new series—*by the Society.*

Memoirs of the Astronomical Society of London, vol. 5th—*by the Society.*

Report of the First and Second Meetings of the British Association for the advancement of Science—*by the Yorkshire Philosophical Society.*

Proceedings of the Natural History Society of the Mauritius, for June, 1833—*by the Society.*

Proceedings of the Geological Society of London, No. 28—*by the Society.*

Madras Journal of Literature and Science—*by the Madras Literary Society.*

Journal Asiatique, Nos. 58, 62, and 63—*by the Asiatic Society of Paris.*

Thirteenth and fourteenth volumes of the Transactions of the Batavian Society—*by the Society.*

Second Annual Report of the Council of the Naval and Military Library and Museum—*by Messrs. Bagshaw and Co. for the Council.*

Von Hammer's History of the Ottoman Empire, 9th volume, and some loose tracts—*by the Author.*

Jahrbucher der Literature, vols. 57, 58, 59, and 60—*by Councellor Von Hammer.*

Marcoz, Astronomie Solaire Simplifiee—*by H. T. Colebrooke, Esq.*

De Tassy, Memoire sur le Systeme Metrique des Arabes—*by the Author,*

Leipziger Literature Zeitung, Nos. 206, 207, 208, and 209—*by the Editor.*

D. H. Fitton on the Progress of Geology in England—*by the Author.*

Ditto's Geological Sketch of the Vicinity of Hastings—*by the Author.*

A short system of Polite Learning, compiled and translated by Maha Raja Kalí Kissen Bahadur—*by the Translator.*

Select Extracts from Lord Chesterfield's Advice to his Son, translated into Bengalee, by Radhanath Dey—*by the Translator.*

Stocqueler's Fifteen Months' Pilgrimage through untrodden tracts of Khuzistan and Persia—*by the Author.*

The following books were received from the Book-sellers:

Lardner's Cabinet Cyclopedia—British Admirals, 1st vol.
Iron and Steel, 2nd vol.
Christian Church, 1st vol.

Library of Useful Knowledge—Waddington's History of the Church.
Spain and Portugal.

* Printed on the cover of the present number.

Lyell's Principles of Geology, 3rd vol.

Theatrum Pontificiale, 5 vols.—*purchased by the Society.*

Memoires Concernant les Chinois, 14 vols.—*presented by the Secretary.*

Read, a letter from Mr. A. Boue', Foreign Sec. of the Geological Society of France, offering an exchange of their publications against the Journal and Transactions of the As. Soc. *Resolved,* that the exchange be made with pleasure, through the Society's Agent in London.

Read, also letters from Professor Von Hammer, the Secretaries of the Philadelphian and Batavian Societies, &c. relative to the works detailed above.

Antiquities, Statistics, &c.

Read, a letter from Mr. Tufnel, Sec. of the Right Honorable the Governor of Ceylon, presenting copies of some inscriptions in the Nágarí character, collected by Captain Forbes of the 78th Highlanders, agent in the Matele district.

Thousands of inscriptions, in the same character, are stated to be found in the island: but we have not yet any clue to the relative value of these letters in the modern Nágarí alphabet. They are evidently identical with those of the Kanouj coins* and with the inscriptions referred by Mr. Stirling to the Buddhists, or Jyns; which their occurrence in Ceylon certainly tends to confirm.

Read, a letter from E. Stirling, Esq. submitting a tabular statement of the price of grain at Alligurh, from our first possession of the country, to 1832.

A statistical report on the population of the town and district of Múrshedabad, drawn up by Mr. H. V. Hathorn, was submitted by Mr. J. R. Colvin.

[We shall give an abstract of these statements in our next.]

Read, a note from Mr. J. H. Stocqueler, presenting some coins, collected during his travels in Europe.

A Fac Simile of an Arabic Inscription, cut in an escarpment of the rock at the Fort of Chanderí, was presented by Dr. J. Tytler, in the name of Lieut. Macdonald; from whose letter, the following extract was read:

"I have discovered an ancient inscription at Chanderí, near which I am now encamped. This place now belongs to Scindia, who took it from the former Raja, 20 years ago. The Fort of Chanderí, which consists of a sandstone wall, flanked by circular towers, built upon a steep hill, was in former days considered impregnable. Colonel Baptista, of Scindia's service, succeeded after a five months siege in starving out the Bundela garrison, and it is now occupied by Marhatta troops. To my inquiries into the ancient history of the place, I could obtain no satisfactory information. The ignorant Marhattas and Bundelas could only name one famous Raja, Sisupal, who flourished in the days of Hindu supremacy, and founded this place. It was afterwards rendered famous by being the residence of Alemgir for a short period. The ruins of mosques, saraís, madrissas, and baolies, mahals and zenánas, indicate its former magnificence under the Musulman sovereignty. There are many ancient inscriptions, but I selected the accompanying, which I found upon a famous ghât or passage which has been cut with stupendous labour

* See page 415 and p. 317.

through a sold rock 100 feet high. This ghât which leads from Chanderí through a sandstone ridge into the adjacent country is in itself a lasting monument of the gigantic undertakings of the Musulman sovereigns, but to the modern inhabitants even the name of the monarch who accomplished this great excavation is unknown. I hope therefore that this inscription will rescue it from oblivion.

" The inhabitants of this country view our trigonometrical operations with suspicion and dread. They cannot comprehend the object of burning lights upon the summits of distant hills, and they can only atribute it to some black art, or *jadu*, by which we wish to take possession of their country. " The weather is getting hot, the thermometer ranging between 88° at sunrise, and 108° at 2 P. M. in my tent.

18*th May*, 1833, *Camp near Chanderí.*

The inscription, after insertion of the second *Sura* of the Korán, called *Ayet-ul-Kursí*, sets forth that the lofty gate of Gumtí and Kerolí, near the tank, were erected by Júman Khán, son of Shér Khán, by order of the Sultán-us-Salatín Ghias-ud-din, on the 14th *Jumád-us Sáni* A. H. 700 (A. D. 1301).

Physical.

Letters from Lieut. Burt, Engineer, of Allahabad, dated 26th August, and from Lieut. Newbolt, of Malacca, 11th July, were read, intimating that they had dispatched shells and geological specimens, which have not yet reached their destination.

Specimens of coal, lignite, pyrites, &c. from Kyook Phyoo, were presented in the name of Lieut. Foley.

[A note on the subject of Lieut. Foley's discoveries will appear in our next.]

Specimens of the fossil shells discovered by Dr. H. H. Spry, Corresponding Member, Ph. Cl. in digging a well near Ságar.

These are the specimens alluded to in a notice published in the July number of the Journal (page 376), announcing the discovery of fossil shells, 17 feet below the surface. Dr. Spry's account has not been yet received, it may suffice therefore to state that the shells are of one species, all left-handed, and precisely the same as those discovered by Dr. Spilsbury, silicified in indurated clay, near Jabalpur, and described in the Proceedings of the Society for April, (p. 205) ; these however are in their natural state, imbedded in a loose cellular wacken, the white granular appearance of which is derived from silex in a white crumbling state, lining the numerous cells of the matrix as is often observed in the geodes of zeolite and heliotrope. Both above and below the shell stratum are beds of wacken, a basaltic clay, becoming harder below, and more earthy above ; the surface being the common black cotton soil, abounding throughout the trap district. The same shell deposit will probably be found to extend over a considerable field.

On turning to Dr. Voysey's description of the shell stratum in the Gáwilgarh hills, a perfect identity is observable in the thickness and nature of the superincumbent and subjacent beds of wacken and basalt : the shells however are described by him as conus or voluta, but as they were much broken and compressed, they were probably not easily recognized, and may have been after all identical with the present shells. They bear some resemblance to the common *ampullaria* of the tanks and jheels of Upper India, described by Mr. Benson, Gleanings, i. p. 265. The fossil shell however has some specific distinctions, in its more

oval form, and the constant reversion of the wborls. Should it turn out to be an *ampullaria*, it will be a proof of fresb water lakes, co-existent witb the emission of tbe Upper Ságar trap, and perhaps with the fossil bone deposit, and as both by Voysey's testimony and by that of Dr. Spry the shell bed bears all the appearance of a regular stratum—it will serve as a mark of distinction between the older and more recent volcanic emissions of that extensive field.

Further specimens of fossil bones and of shell breccia, and the fossil jaw of an elephant; also specimens of the rock on which the bones were discovered, near Jabalpúr, by Dr. Spilsbury. [A note and illustrative section will be given in our next.]

A stuffed eagle from Nipal, and a pole-cat, presented by Captain Roxburgh.

Two specimens of the nest of the Tailor bird—by S. P. Stacy, Esq.

A report from the Curator was submitted on the subject of a collection of insects and shells, which had been purchased in anticipation of the Society's sanction, for the Museum, at an expence of Rupees 100. The collection was made in the Silhet and Kasya hills, and contains several new species, particularly one of a *paludina*, first described by Mr. Benson, in the first number of the Journal. A paper on the subject of this shell, by Dr. J. T. Pearson, was read, and the purchase of the collection was sanctioned.

The thanks of the Society were voted for the several contributions of the evening.

MADRAS LITERARY SOCIETY AND AUXILIARY OF THE ROYAL ASIATIC SOCIETY.

Thursday, 8th August, 1833.

The Right Honorable Sir F. Adam, K. C. B. Present. Honorable Sir R. Palmer, President, in the Chair.

An able and interesting paper on the rise and early history of the Syrian Christians on the Malabar Coast, by the Venerable the Archdeacon, was read to the meeting by the learned author, to whom tbe thanks of the Society were unanimously voted. It was further resolved, that tbe paper in question be adopted by the Society and be set aside for publication.

It was then proposed by Lieut.-Col. Coombs and seconded by Lieut.-Col. Cullen.

That it is desirable with reference to several interesting memoirs and papers which have already been submitted to the Society, and to others wbich may hereafter be received, to adopt means for giving them earlier publicity tban the necessarily distant and slow publication of the Society's transactions will admit; and, that independently of papers read before the Society, and of notices of their meetings and proceedings, the publication under the auspices of the Society of a monthly or quarterly journal, similar to the Asiatic Journal of Calcutta, would, by affording a suitable vehicle for occasional essays and papers connected with objects of oriental literature and science be in strict furtherance of the professed object of the Society, and likely to prove if adequately supported and encouraged, eminently and extremely useful.

The foregoing resolution having been discussed, was agreed to, and it was resolved to refer the same to the Committee of Papers in the Asiatic Department, to arrange the details and adopt the necessary measures for carrying the plan into effect. Several works were presented and thanks voted for the same.

VII.—Analysis of Books.

Seventeenth volume of Asiatic Researches, *or Transactions of the Society instituted in Bengal for inquiring into the History, the Antiquities, the Arts and Sciences and Literature of Asia. Calcutta,* 1832.

This volume is prefaced with an address from the Society to its late Secretary Mr. H. H. Wilson, upon the occasion of his departure to Europe, which will be found printed at length in the Journal, vol. i. p. 563.

I. The first paper is a *Statistical Report on the Bhotia Mehats of Kemaon, by G. W. Traill, Esq. Commissioner.* It forms a supplement to the more elaborate report by the same officer on the district of Kemaon, printed in the sixteenth volume of the Asiatic Researches, 1828.

The Bhot Mehals, forming in extent one-third of the Kemaon province, are bounded at the north by the table-land of Tibet, on the south they extend to the base of the Himálaya range, and are irregularly defined, piercing through the barrier of the snowy range at the passes of the five principal rivers, *Mana* and *Níti*, on the feeders of the *Ganges; Juwar, Darma*, and *Byanse*, on those of the *Sarda* or *Gogra.*

These limited valleys, or gorges, are the only productive and inhabitable parts of Bhot, the rest consisting of snow and barren rock. They are elevated 6000 feet above the sea, while the peaks around them tower to 20 and 25,000 feet. The Bhotias insist that the zone of snow is continually extending, and cutting off passes from one valley to another, which were formerly passable at least for a few days in the year. The only accessible roads now follow the direction of the streams, and owing to avalanches (*húin gul*) and slips (*paira*) require constant toil for their preservation. The *Níti* is the most practicable pass, but at many points ponies and cattle are forced to be raised or lowered by means of slings passed round their bodies!

There are but 59 villages and 1325 houses, and about 10,000 inhabitants in this mountainous district, of whom nine-tenths are Bhotias or Tibetans.

For half the year the ground is covered with snow, and an interval of four months without a fall of snow, forms an uncommonly favorable summer!

Phapar and *Ugal*, two varieties of buck-wheat, *Uä Jao* and *Jao*, beardless and common barley, are the principal agricultural products of the province. The *Phaper* seem indigenous, as it is found wild on all high mountains. Wheat and *Marsa*, a species of Amaranthus, yield an uncertain crop.

"Turnips and leaks are the only vegetables raised in Bhot! but many useful roots and herbs are spontaneously produced, among these are, the wild garlic, celery, rhubarb, frankincense (*mari* or *balchar*), *laljari, chora, bhotkes*, and *kathi*, objects of export to Hindustan. The rhubarb is somewhat inferior in its color and properties to the Turkey, and the Bhotias do not take it inwardly, though they apply the powder to wounds and bruises: it is also used as an ingredient in the formation of a red dye, in conjunction with *Manjith* (very abundant here) and potash."

Among the fruits, Mr. Traill enumerates the gooseberry, currant, raspberry, strawberry, and pear. Walnuts and hazlenuts are common, but small; apricots and peaches do not thrive. Oaks, pines, the celebrated *Deodar*, and the *Suryi* or Arbor vitæ, with trunks of 20 and 25 feet in circumference, are common; to them succeed the Rhododendron, the king pine, the yew, the *Naspati*, or white Rhododendron, (used as snuff,) *Bindhara* or juniper, and above all, the *Bhoj* (*bhuria*), or birch on the very verge of perpetual snow*.

* See note in page 337.

The domestic animals are the common hill black cattle, and the *Surágai* or *Yák* of Tartary; the *Jábu* and *Garju* are prolific mules between these two, very serviceable for carriage: sheep and goats, used also for burden; stout ponies, called *Gunts*, dogs, (the *Buansu*, tamed,) and cats. The wild animals are the *Barjí* or tawny bear; the *Bharal*, wild sheep; *Kasturi*, musk deer; the *Bhia*, a small brown marmot; the *Kukar*, ferret, and rats with short tails.

The birds peculiar to *Bhot* are the falcon and hawk, the *Hiún-wál* (bird of snow), ptarmigan; *Múkao*, wild pigeon, and *Kyang*, or chough, with scarlet bill and legs. The *Bhaunr* or wild bee builds its nest on the southern aspect of the Himálaya.

Of minerals, Mr. Traill mentions iron, sulphur, and yellow orpiment. The fossil bones called *Bijli hár* are chiefly found at the crest of the *Níti* pass, full 17,000 feet high. Hot springs are numerous, and there is reason to suspect that a volcano exists on the *Nanda Devi* peak.

We have not space to follow the author into the history and manners of the people who inhabit this secluded tract: they derive their origin from Tibet but shew an equal admixture of Hindú in their institutions. It would have been interesting to have added a vocabulary of words in the unwritten *Darma* dialect spoken by the aborigines of the country.

Situated between the Tibetan and Gorkha powers, the Bhots have had to pay for the protection of both: and being the key of commercial intercourse between Tartary and Hindustan, the revenue *jama*, raised from this limited population, on the introduction of the British Government, in 1872, *Sambat*, amounted to so large a sum as Rupees 11,565. By an enlightened policy, the transit duties were soon after all abolished, and though the direct receipts were thus reduced to one-half, the increase of trade must have amply compensated for the loss.

The principal exports from *Bhotia* to *Tibet* or *Híundés* (snowland) consists of grain, calico, hardware, broadcloth, gúr, sugar, and timber. The imports are salt, the natural produce of lakes in *Híundés*, 15,000 maunds: *tincal* or *borax*, also the natural produce of a lake; in this article there was much speculation for the British market, and the import increased from 1500 to 20,000 maunds in 1818-19, a quantity far exceeding the demand in Eugland. The supply has since fallen to 7 or 8000 mds. The other imports are wool, shawl-wool, gold dust, and a few trifling articles. As the imports from 1816 to 1821 much exceeded the exports, a large amount of Furukhabad rupees found their way to *Híundés*, of which they have become the favorite currency.

Mr. Traill's able report terminates with a few remarks on the province of *Híundés*, of which a full account has already been given in the Journal in Mr. A. Csoma's Geographical Notice of Tibet, (vol. i. p. 124.)

II.—The next paper is an *Essay on the mode of performing the arithmetical operation of the extraction of roots, as practised by the Arabs, and given in the Ayoun-ool-Hisab, by John Tytler*. At first sight this paper appears rather lengthy, but its subject is one which it is difficult to compress so as to render intelligible, and indeed without a diagram it is by no means easy to render it intelligible at all.

The Binomial formula of any power $(a+b)^n$ is $a^n + n\,a^{n-1}\,b + \frac{n.\,n-1}{2}$ $a^{n-2}\,b^2$ &c....... b^n. This may be considered as consisting of two terms a^n and $n\,a^{n-1}\,b + \frac{n.\,n-1}{2}\,a^{n-2}\,b^2 \,\ldots\ldots\, b^n$. Supposing a given number to consist

of more than n figures, and consequently to be of the form $e\times 10^n + r$ then if u^n be the nearest approximate n^{th} power to e and if $e\times 10^n - u^n \times 10^n = v$ and $u^n \times 10^n$ be supposed to expound a^n and $v+r$ to expound $n\, a^{n-1}\, b + \frac{n.\, n-1}{2} a^{n-2}\, b^2 \ldots\ldots b^n$, the complete nth root of $e\times 10^n + r$ will be found by finding an approximate nth power to e, and then seeking such a number as when substituted for b in $na^{n-1}\, b + \frac{n.\, n-1}{2}\, a^{n-2}\, b^2 \ \ldots.\ b^n$ will render the sum of this expression and the product of the nearest nth power already found into 10^n, less or not greater than $e\times 10^n + r$ or $(a+b)^n$. And this operation is to be repeated according to the number of figures in $(a+b)^n$.

Our books of arithmetic contain nothing farther than the above statement, and leave the mode of finding the second number of the root, and of its successive involutions and multiplications into its proper co-efficients, entirely to the student. The Arabian arithmeticians, with a good deal of ingenuity certainly, (whether well or ill directed is another question,) have invented a table or diagram in which, by a sort of mechanical process, the sought number b by the bare process of multiplication into one figure, and addition to the number above it, is successively involved to all its powers, multiplied into all its co-efficients, and the sum of the whole found.

The Arabians give to their diagram the quaint name of *Shukul-i-Mumburee*, or Pulpit, or, as Mr. Tytler more grandly translates it, Anabathroidal diagram. The figure consists of ascending steps like those of the stairs of a Mohammadan pulpit. The etymologies of by far the greater part of our technical terms are not more rational.

The Arabian operation, in fact, is a very careful mode of finding the result of $n\, a^{n-1}\, b + \frac{n.\, n-1}{2}\, a^{n-2}\, b \ldots.\ b^n$ so as not to repeat any of the steps or perform the same calculation twice over. With our present improved methods, it is seldom that the arithmetical extraction of roots of high powers is performed; but were it often required, we should soon find the necessity of attention to this matter, and of some system in arranging our operations, so as to avoid doing the same thing over and over again.

Such mechanical contrivances have been employed by the greatest Mathematicians: it will be sufficient to instance the celebrated square, almost on the principles of a magic square, invented by Sir I. Newton, for solving equations by means of converging series. A mind curious in tracing analogies, might discover in the Arabic anabathroidal diagram, some traces of that reasoning which must have led to the discovery of the wonderful calculating machine of Mr. Babbage.

To give an idea of the Arabian method, we shall here extract the approximate 6th root of 166,571,800, which is the two first steps of the example given by Mr. Tytler. In the original diagram longitudinal lines are drawn between each two figures: for those we have substituted dots, and the several steps of the operation are numbered I. (which is at the bottom) II. III. &c. To abbreviate, let 10 be denoted by ϕ, 166 by e, 571800 by r, 2 the approximate 6th root of 166 by a and 3 by b, and the effect of the several operations will be as marked in the following diagram.

	2	
	166	$= e$
VI.	.64	$= \text{V} \times a = a^6$ or 6th power of approximate root of e or first Subtrahend.
	3	
VII.	102571800	$= (e - a)\ \phi^6 + r =$ Resolvend.
XLVI.	.84035889	$= \text{XLV} \times 3 = 6\ a^5\ \phi^5\ b + 15\ a^4\ \phi^4\ b^2 + 20\ a^3\ \phi^3\ b^3 + 15\ a^2\ \phi^2\ b^4 + 6\ a\ \phi\ b^5 + b^6$ or second Subtrahend.
XLV.	.28011963	$= \text{XLIV} + \text{XVII} = 6\ a^5\ \phi^5 + 15\ a^4 \phi^4\ b + 20\ a^3\ \phi^3\ b^2 + 15\ a^2\ \phi^2\ b^3 + 6\ a\ \phi\ b^4 + b^5.$
XLIV.	..8811963	$= \text{XLIII} \times 3 = 15\ a^4\ \phi^4\ b + 20\ a^3\ \phi^3\ b^2 + 15\ a^2\ \phi^2\ b^3 + 6\ a\ \phi\ b^4 + b^5.$
* XVII.	. 192.....	$= \text{XVI} \times \phi^5 = 6\ a^5\ \phi^5.$
XVI.	192......	$= \text{XV} + \text{V} = 6\ a^5.$
XV.	160......	$= \text{XIV} \times\ a = 5\ a^5.$
V.	. 32......	$= \text{IV} \times a = a^5.$
XLIII.	..2937321	$= \text{XLII} + \text{XXV} = 15\ a^4\ \phi^4 + 20\ a^3\ \phi^3\ b + 15\ a^2\ \phi^2 b^2 + 6\ a\ \phi\ b^3 + b^4.$
XLII.	...537321	$= \text{XLI} \times 3 = 20\ a^3\ \phi^3 b + 15\ a^2\ \phi^2\ b^2 + 6\ a\ \phi\ b^3 + b^4$
* XXV.	..240....	$= \text{XXIV} \times \phi^4 = 15\ a^4\ \phi^4.$
XXIV.	240......	$= \text{XXIII} + \text{XIV} = 15\ a^4.$
XXIII.	160......	$= \text{XXII} \times a = 10\ a^4.$
XIV.	. 80......	$= \text{XIII} + \text{IV} = 5\ a^4.$
XIII.	. 64......	$= \text{XII} \times a = 4\ a^4.$
IV.	. 16......	$= \text{III} \times a. = a^4$
XLI.	...179107	$= \text{XL} + \text{XXXI} = 20\ a^3\ \phi^3 + 15\ a^2\ \phi^2\ b + 6\ a\ \phi\ b^2 + b^3$
XL.	19107	$= \text{XXXIX} \times 3 = 15\ a^2\ \phi^2\ b + 6\ a\ \phi\ b^2 + b^3.$
* XXXI.	...160...	$= \text{XXX} \times \phi^3 = 20\ a^3\ \phi^3.$
XXX.	160......	$= \text{XXIX} + \text{XXII} = 20\ a^3.$
XXIX.	. 80......	$= \text{XXVIII} \times a = 10\ a^3.$
XXII.	. 80......	$= \text{XXI} + \text{XII} = 10\ a^3.$
XXI.	. 48......	$= \text{XX} \times\ a = 6\ a^3.$
XII.	.32......	$= \text{XI} + \text{III} = 4\ a^3.$
XI.	. 24......	$= \text{X} \times a = 3\ a^3.$
III.	..8......	$= \text{II} \times a = a^3.$
XXXIX.	6369	$= \text{XXXVIII} + \text{XXXV} = 15\ a^2\ \phi^2 + 6\ a\ \phi\ b + b^2.$
XXXVIII.	369	$= \text{XXXVII} \times b = 6\ a\ \phi\ b + b^2.$
* XXXV.	.....60..	$= \text{XXXIV} \times \phi^2 = 15\ a^2\ \phi^2.$
XXXIV.	.60......	$= \text{XXXIII} + \text{XXVIII} = 15\ a^2.$
XXXIII.	. 20......	$= \text{XXXII} \times\ a = 5\ a^2.$
XXVIII.	. 40......	$= \text{XXVII} + \text{XX} = 10\ a^2.$
XXVII.	. 16......	$= \text{XXVI} \times a = 4\ a^2.$
XX.	. 24......	$= \text{XIX} + \text{X} = 6\ a^2.$
XIX.	. 12......	$= \text{XVIII} \times\ a = 3\ a^2.$
X.	. 12......	$= \text{IX} + \text{II} = 3\ a^2.$
IX.	..8......	$= \text{VIII} \times\ a = 2\ a^2.$
II.	..4......	$= \text{I} \times \text{I} = a \times a = a^2.$
* XXXVII.	123	$= \text{XXXVI} \times \phi + 3 = 6\ a\ \phi + b.$
XXXVI.	. 12......	$= \text{XXXII} + a = 6\ a.$
XXXII.	. 10......	$= \text{XXVI} + a = 5\ a.$
XXVI.	..8......	$= \text{XVIII} + a = 4\ a.$
XVIII.	..6......	$= \text{VIII} + a = 3\ a.$
VIII	..4......	$= \text{I} + \text{I}$ or $a + a = 2\ a.$
I.	..2......	$= a$ or approximate root of e.

The only parts that require explanation are those steps of the operation marked with an asterisk. In these it is to be remembered, that if there be a given row of figures as 8811963, and there be added to, or subtracted from it, another row, so that

the units of the second may be under the figure in the n^{th} place of the first, the tens of the second under the $(n+1)^{th}$ place of the first, the hundreds under place $n+2$ &c. this is in reality adding or subtracting the product of the second row by 10^{n-1}. Thus 8811963

$$\begin{array}{r} 8811963 \\ 192 \\ \hline 8813883 \end{array} \text{ is in reality } 8811963 + 192 \times 10.$$

$$\text{Again } \begin{array}{r} 8811963 \\ 192 \\ \hline 8831163 \end{array} = 8811963 + 192 \times 10^2$$

$$\text{and so on to } \begin{array}{l} 8811963 \\ 192 \\ \hline 28011963 \end{array} = 8811963 + 192 \times 10^5.$$

The course of the otber operations, by which the co-efficients of the Binomial Theorem are formed by successive additions of the several orders of figurate numbers, will be obvious to any one who takes the trouble of tracing them in the order of the diagram: for the mode of repeating the whole operation, so as to find roots of many figures, we must refer to the original paper: a little consideration however of the diagram already given will render that obvious also.

The method here detailed gives no more than the integral figures of the root, and the Arabs being unacquainted with decimal fractions, could go no farther. To remedy this, they employ a formula for finding a fraction, to be added to the integral part of the root, so as to give a nearer approximation.

Their formula is tbis; Let m be the approximate nth root of M and $M - m^n = r$ then $\left[m + \frac{r}{(m+1)^n - m^n}\right]^n$ will be less than M and consequently $m + \frac{r}{(m+1)^n - m^n}$ is a nearer approximate nth root of M, as may be easily proved. In this case r and $(m+1)^n - m^n$ are found by the last revolution of operations in the Anabathroidal Diagram.

This formula however is imperfect, and when applied to high powers, produces great errors: in the square it never can be greater than $\frac{1}{4}$, but in seeking, for example, the 6th root of 396, the error is more than $152\frac{1}{4}$. This imperfection the Arabians appear to have been anxious to remedy: their method is this; if in the above formula $n=2$, that is, if the root sought be the square root, then $m + \frac{r}{(m+1)^n - m^n}$ becomes $m + \frac{r}{2m+1}$ and the difference between the square of this and M may approximate to $\frac{1}{4}$. To remedy this, the Arabian arithmeticians instead of $m + \frac{r}{2m+1}$ assume the formula $m + \frac{2r}{4m+1}$ and then $M - \left(m + \frac{2r}{4m+1}\right)^2$ that is $m\ \ + r - \left(m + \frac{2r}{4m+1}\right)^2 = \frac{(4m+1)r - 4r^2}{(4m+1)^2}$.

Now this expression is either positive or negative. If positive, Mr. TYTLER shews, it never can exceed $\frac{1}{16}$; if negative, then since a negative deficiency is an excess, this shews that the assumed root is greater than the truth, and in tbis case the excess of its square above M will increase according to the value of m, and will approximate to $\frac{1}{2}$.

These results the author easily produces by the application of fluxions. The puzzle is, to understand by what reasoning the Arabians without any means of

this kind, hit upon a convenient formula such as $m + \frac{2r}{4\,m + 1}$. Though the formula, when found, appears simple, yet the difficulty of actually finding it, with their limited means, must have been very great. It was like tbe Druids elevating the immense blocks of Stonehenge without mechanics. Most probably it was discovered by long and laborious tentation.

The autbor then discusses the effects of assuming as the approximate square root the formula $m + \frac{r\,z}{2\,m\,z + 1}$ in which z is indefinite ; but tbis, as foreign to tbe Arabs, we omit, and sball sum up the whole in his words—

" We may hence form some judgment how much the old arithmeticians must have been perplexed and retarded by the labour of long multiplication. We, who enjoy the benefits of the great discovery of Logarithms, can now scarcely form an estimate of the difficulties with which they had to contend from this want, and the facilities which we enjoy from their use. While, therefore, the Arabian method of extraction may inspire us with more gratitude to Lord Napier, we must not too hastily condemn it as uselessly laborious, till we can show that, without a knowledge of his discovery, we could have more happily succeeded in the facilitating and abbreviation of calculation. Should, after all these considerations, the intention of the Arabian operation be thought of little value, and the labour employed to accomplish it misused, yet the artful contrivances by which it is attained, and the skilful adaptation for this purpose of the simple principle of the variation of the signification of symbols from tbe variation of their situation, must, I think, in justice, always cause the Pulpit Diagram to be considered a deserving monument of Arabic ingenuity."

The Author concludes his essay—

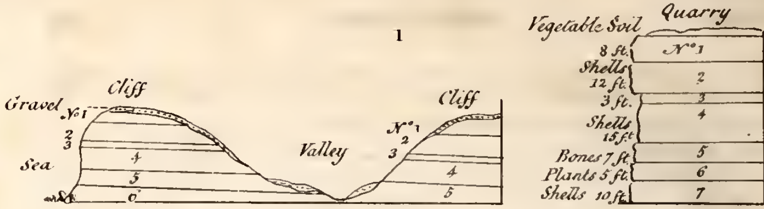
"With an acknowledgment of my obligations to my very intelligent friend Dewan Kanh Jee of Patna ; by him I was furnished with the extract of the Ayoun-ool-Hisab. His treatise of Arithmetic formerly mentioned*, and his oral explanations enabled me to comprehend the obscure and studied brevity of tbe Arabian Author ; and from the same sources I derived those observations on the fractional part of the root which form the basis of the concluding paragraphs of the present Essay."

The treatise of Arithmetic here alluded to, and named by its author, the Khizanut-ool-Ilm, is described in vol. xiii. of the Researches, p. 466. It is a very large work, consisting of three parts : first, an account of Arabian Mathematical Science ; next, of that of the Hindus, and lastly, as much of the European as the author was acquainted with. The whole, we are happy to say, is in the course of printing by the Committee of Public Instruction, and will, when complete, form an invaluable store of information respecting Oriental Mathematics.

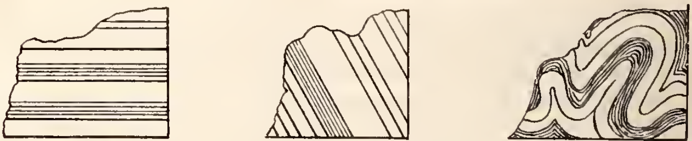
The European part of the Khizanut-ool-Ilm consists of two sections : first, a complete translation by the Dewan of Bonnycastle's Algebra ; secondly, an extract consisting of a collection of Geometrical Problems from tbe papers of tbe celebrated Tufuzzool Hosain Khaun of Delhi. This person during his life, was considered, we believe, tbe best Mohammadan mathematician in India, and he appears to have employed his time in translating European mathematical works into *Arabic ;* after his death, which took place some years ago, Government, we are told, made strong efforts to obtain his MSS. but in consequence of legal disputes between his relations these were unsuccessful, and the fate of the papers is probably not known. It is much to be wished that they could be procured.

* See Essay on the Binomial Theorem, vol. xiii. of the Researches, p. 466. The Dewan here mentioned is since dead.

1



2

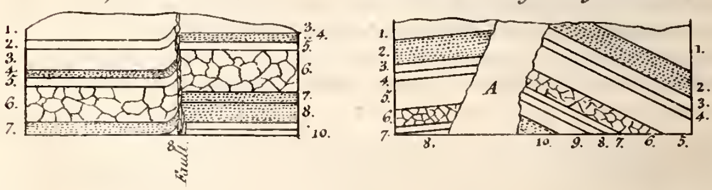


Horizontal Beds. Inclined Beds. Dip. 60°. Twisted Beds.

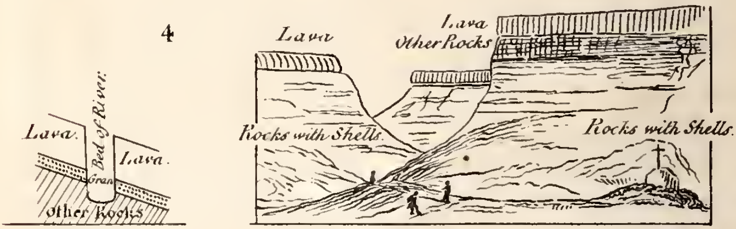
3

Fault, or Dislocated Beds.

Fault, or Dislocated Beds. Rock A cutting through other rocks.



4



5

The above facts, the pains taken by Dewan KANH JEE, in translating from English, which he understood very imperfectly, and in which (as he acknowledges) he was greatly assisted by the kindness of HENRY DOUGLAS, Esq. of Patna, and his extracts from the papers of the Delhi mathematician, are strong proofs, notwithstanding the present fashionable doctrines, of the value set by Natives on translations from English works, when well chosen and judiciously executed.

TUFUZZOOL HOSAIN KHAUN's choice of *Arabic* for the vehicle of his translations is also a proof that intelligent Natives do not see the advantages of proscribing that language so clearly as we.

[*To be Continued.*]

II.—*Madras Journal of Literature and Science, published under the auspices of the Madras Literary Society and Auxiliary Royal Asiatic Society, edited by the Secretary, No.* 1, *October* 1833, *price to Subscribers* 3 *Rs. per quarter.*

We cannot but feel highly complimented by the appearance of a new periodical at Madras, professedly founded on the model of our own journal, and imitating our arrangements even to the style of the title page, the price, the number of pages, and the gratuitous conduct of the editorial department. We look upon it not as a rival but as a powerful auxiliary, and we hail it as a guarantee of the revival of the efforts of the Madras Literary Society. The publication of Researches in an occasional quarto volume at distant periods has been adduced as a bar rather than an incentive to contributions of a learned nature, while the limited sale of such works makes the printing charge fall heavy on a small Society: this has been partially felt in Calcutta; and it has led at Bombay, as at Madras, to the absorption of the institutions there into branches of the Royal Association at home. Under the new system however of giving rapid publication, free of cost, to short interesting and ephemeral papers (in which the Bombay Geographical Society may also easily join by a similar journal for the west of India), the independence and orientality of each might still be assured; while by a combination of the means and labours of the three Indian Societies, a volume of Researches might simultaneously be kept in hand at Calcutta for their more erudite and lengthened communications. We have not room to notice the contents of the Madras Journal at present, but we shall not scruple to extract matter that will be interesting to our own readers. We sincerely regret the untimely end of Lieut.-Colonel COOMBS, whom we perceive to have been one of the chief promoters of its establishment.

VIII.—*Miscellaneous.*

Circular Instructions from the Geological Society, for the Collection of Geological specimens, with a plate.

[We beg the attention of our Indian geologists to these simple instructions; to which we have only to add that numbers should be put on the stones, where possible, as paper labels are soon destroyed by insects in this country.]

1. The Geological Society begs to impress upon the minds of all collectors, that the chief objects of their research should be specimens of all those rocks, marls, or clays, which contain shells, plants, or any sort of petrifaction.

2. The petrifactions should, if possible, be kept united with portions of the rock, sand, or clay, in which they are found; it being more desirable that the mass should

be examined carefully when brought to England, than that any separation of the shells should be attempted at the time of their collection. This injunction, however, does not apply to those cases in which the shells fall readily from their surrounding matrix; but, in this event, great care must be taken of the petrifactions, by rolling them in paper, or some soft material.

3. If several varieties of stone are seen in the same cliff or quarry, and particularly if they contain any petrifactions, specimens of each should be taken, and numbered according to their order of succession; marking the uppermost No. 1., and thence descending with Nos. 2, 3, &c., making as correct an estimate as time will permit of the thickness of the beds. None of these specimens need be more than 3 in. square, and one and a half or two thick. (*fig.* 1.)

4. If the rocks are stratified, that is, divided into beds, state whether they are horizontal, inclined, or twisted. If inclined, observe pretty nearly at what angle, and to what point of the compass they dip; if twisted, a sketch, however slight, is desirable. — N. B. The true dip can seldom be ascertained without examining the beds on more sides than one. (*fig.* 2.)

5. One kind of rock is occasionally seen to cross and cut through the beds of another. In such a case, observe whether the beds are in the same plane on each side of the intruding rock; if not, mark the extent of the disturbance, and also if there be any difference in the nature of the stone of which the beds are composed, at those points where they touch the intruding rock. Take specimens from the junction, and make a sketch of it. (*fig.* 3.)

6. Where there are wells, get a list of the beds sunk through in digging them; specifying the thickness of each stratum in its order, from the surface downwards.

7. In volcanic districts, procure a list of the volcanoes now or recently in action, and of those which are extinct; stating their position, their distance from the sea or any great lake; the extent, nature, and, if possible, the age, of particular streams of lava, or the relative age of different streams: also whether the lava currents conform to the valleys, or are seen at different heights above the present rivers; and also if any gravel beds be discoverable beneath the streams of lava. (*fig.* 4.)

8. Note the names of all places known to contain coal, bitumen, salt, alabaster, metallic ores, or any valuable minerals, specifying their extent, and the nature of the rocks in which they occur; but do not bring away large quantities of iron ore, spar, salt, &c.

9. In cases of coal-pits, specimens of the coal itself and of the beds passed through to obtain it (especially when plants have been found) will be valuable. State whether limestone, iron ore, or springs of bitumen are found near the coal; and if the limestone contains shells, collect abundance of them.

10. Make particular inquiries whether, in digging gravel-pits, or beds of surface clay, mud, and sand, the workmen are in the habit of finding any bones of quadrupeds; and obtain as many of them as possible, selecting particularly teeth and vertebræ.

11. Search also for bones in cracks of rock, and in caverns. In the latter, the lowest pits or hollows are most likely to contain bones; and if the solid rock be covered with a crust of spar or marl, break through it, and dig out any bones, horns, or pebbles from beneath. (*fig.* 5.)

12. Observe if the surface of the country be strewed over with large blocks of stone; remark whether these blocks are angular or rounded, and whether they are

of the same or a different nature from the stratum on which they are laid. If the latter, endeavour to trace them to their native bed. Note the different heights at which gravel is found, and whether or not it is composed of the same rocks as the adjoining country.

13. Nautical collectors are requested to separate and preserve any shells or corals which may be brought up, either with the lead or the anchor; noting the depth and the locality.

14. On coasts where there is a considerable ebb tide, and where the shore consists of rocks or clay containing fossils, some of the best of these petrifactions may be looked for, by breaking up with a pick-axe the shelving beds exposed at low water.

15. In making sections, or memorandums, distinguish well upon the coast, between masses which have simply slipped and fallen away, and the real cliff itself.

16. When drift wood is met with at sea, collect pieces of it: note the longitude and latitude, the distance from the nearest land, and the direction of the current by which it has been borne. Examine well the state of the floating mass, and see whether any roots or leaves be attached to it.

17. Every specimen should be labelled on the spot, or as soon after collection' as possible, and then rolled in strong paper, or any soft material, to protect its edges.

18. A heavy hammer to break off the specimens from the rock, and a smaller one to trim them into shape, are indispensable. If the larger hammer have a pick at one end, it will be found very useful in digging up and flaking off those thin shelly beds which usually contain the best preserved shells, &c. A chisel or two are also desirable.

19. The recommendation expressed in the instruction No. 1, may be repeated: —That it should be a general maxim with geological collectors to direct their principal attention to the procuring of fossil organic remains, both animal and vegetable. These are always of value when brought from distant countries; especially when their localities are carefully marked; but when the rocks contain no petrifactions, very small specimens are sufficient.

2.—*Mirrors of Fusible Alloy.*

Berzelius has found that by the union of nineteen parts of lead and twenty-nine of tin, fusible alloy is produced, which affords, on cooling in thin plates, very bright surfaces. A convex lens dipped several times into the melted alloy, yielded from the surface dipped, a concave mirror of great lustre. This, mounted upon plaster, was preserved for some time in the air untarnished. Dust destroys these mirrors, which will not bear wiping.—*Traité de Chimie.*

3.—*Liverpool and Manchester Railway.*

It appears from the account of the Company for the half year ending the 31st December last, that notwithstanding a diminution of nearly 74,000 in the number of passengers during July and August, (supposed to have been caused by the cholera), the loss on this account had, in a considerable degree, been made up by the greater quantity of merchandize conveyed, and a reduction in the general expenses of management. The total number of passengers during the half year, was 182,823 —the receipts £43,420. The merchandize conveyed amounted to 86,642 tons—receipts £37,781. The expenses, including £12,646 for repairs of engines, amounted to £48,278, leaving a clear profit of £37,781, which enables the Company to make a dividend, for the half year, of four guineas per share.—*Mech. Mag.*

Meteorological Register, kept at the Assay Office, Calcutta, for the month of October, 1833.

Day of the month.	Barometer reduced to 32° Farh. At 4½ A.M.	At 10 A.M.	At 4 P. M.	At 10½ P. M.	Thermometer in the Air. Minimum at 4½ A. M.	At 10 A. M.	Max. by Reg. Ther.	At 4 P. M.	At 10 P. M.	Depression of moist-bulb Thermometer. At 4½ A. M.	At 10 A. M.	At 4 P. M.	At 10 P. M.	Hair Hygrometer. At 10 A. M.	At 4 P. M.	Rain. Inches.	Wind. Morning.	Noon.	Evening.	Weather. Morning.	Noon.	Evening.
1	,570	,602	,511	,612	81,0	85,9	93,8	88,1	81,8	1,9	3,9	4,7	3,6	96	94		n. e.	*E.*	E.	clear.	cum. nim.	clear.
2	,590	,645	,558	,657	80,0	85,7	101,5	87,4	81,2	2,0	4,4	5,0	3,8	95	93		*E.*	n. e.	s. e.	do	clr.showers	do
3	,650	,694	,631	,682	79,2	85,9	92,4	86,2	81,8	2,0	4,6	5,1	3,8	94	93		n. e.	*E*	E.	do	fine c. s.	do
4	,653	,698	,588	,685	79,9	87,0	100,2	88,5	83,0	1,9	5,5	7,5	4,6	91	87		o.	*E.*	o.	do	do	do
5	,662	,740	,633	,741	81,0	87,0	102,0	90,8	82,3	3,2	5,8	8,7	3,8	92	86		*E.*	n e.	o.	do	do	showers
6	,744	,804	,670	,788	81,6	86,7	94,6	90,2	83,1	3,5	5,2	7,7	5,1	93	87		w.	e.	E.	do	do	clear.
7	,744	,740	,712	,773	81,8	88,0	94,0	81,4	78,2	3,1	6,1	4,4	1,7	92	96	2,28	o.	s. w.	E.	do	cum.strat.	rain.
8	,727	,769	,690	,729	76,7	82,8	88,6	84,2	79,4	0,7	3,8	4,3	1,9	98	96		o.	*n. e.*	n. e.	haze.	foggy.	rn .haze.
9	,670	,750	,652	,732	78,4	82,4	86,2	83,5	78,7	1,4	3,4	3,6	2,0	98	97		n. e.	n. w.	n. e.	clear.	overcast.	do
10	,694	,761	,666	,780	77,0	82,6	85,6	84,5	80,5	1,8	3,5	4,2	2,0	98	96	0,14	n. e.	s. e.	o.	haze.	do	overcast.
11	,742	,826	,733	,836	80,0	83,8	87,3	87,5	78,3	1,6	2,8	3,1	1,5	97	96		n. e.	o.	o.	overcast.	do	do
12	,792	,867	,733	,798	77,3	83,0	92,8	84,7	81,8	1,3	3,3	3,6	3,8	96	95		n.	o.	o.	do	cumuli.	clear.
13	,753	,787	,660	,749	78,2	84,0	93,8	85,9	81,0	3,6	3,5	4,5	3,5	95	93		o.	s. w.	s. e.	clear.	fine.	nwr. clear.
14	,745	,816	,710	,775	78,2	83,3	92,6	85,1	82,6	3,1	4,0	6,3	4,8	94	88	1,26	o.	*n. w.*	o.	rain.	cumuli.	clear.
15	,767	,837	,724	,746	80,7	84,6	95,9	87,1	84,2	2,9	4,4	6.7	5,4	94	87		o.	*s. w.*	o.	clear.	clear.	do
16	,804	,867	,750	,826	84,0	85,9	96,1	88,7	84,8	3,7	5,0	8,4	6,7	93	85		o.	N.	o.	do	do	do
17	,799	,862	,728	,702	81,2	86,3	97,8	90,0	85,1	2,8	7,2	10,6	7,6	90	80		o.	n.	o.	do	cumuli.	do
18	,784	,826	,730	,803	81,0	86,9	94,1	90,0	82,0	4,1	6,0	10,2	3,3	89	80		o. n.	w.	*S.*	do	fine.	do
19	,790	,852	,764	,823	79,2	87,0	94,6	90,5	81,1	1,2	6,0	10,2	2,1	91	81		s.	*s.*	*S.*	do	clear.	do
20	,759	,878	,795	,856	79,3	87,2	93,3	90,3	81,3	1,7	7,5	9,6	3,8	88	86		S.	o.	s.	do	do	do
21	,850	,902	,818	,868	79,2	87,5	95,0	90,2	82,0	1,2	8,5	9,3	4,3	85	90		o.	S.	s.	do	do	cirri.
22	,850	,894	,786	,830	80,2	87,2	94,8	90,0	81,1	2,0	7,4	9,6	4,1	87	83		o.	S.	s.	fog.	do	clear.
23	,832	,900	,842	,922	80,0	87,5	94,0	89,7	79,2	2,2	7,2	9,6	4,2	88	84		s.	s.	E.	clear.	do	cir. cum.
24	,918	,991	,910	,969	78,1	87,0	94,2	89,5	78,2	1,7	6,1	10,0	6,2	90	82		o.	s.	E.	do	do	clear cold.
25	,969	,044	,931	,004	76,7	86,2	97,5	88,5	82,7	3,1	5,7	8,2	5,6	90	86		s. e.	n.	o.	do	do	clear.
26	,964	,050	,902	,962	78,1	86,5	97,1	88,8	78,8	3,0	6,0	9,2	6,3	90	84		o.	o.	n.	do	do	cir. cum.
27	,936	,025	,880	,932	76,4	85,0	93,5	87,0	76,1	3,4	6,0	9,1	4,3	90	84		n.	o.	o.	do	do	rn. nwr.
28	,916	,000	,858	,929	75,8	83,8	90,5	86,1	79,2	3,5	6,0	9,0	6,6	89	85		n. w.	n. w.	*N. W.*	cir. cum.	cumuli.	cum. str.
29	,950	,992	,883	,926	76,1	82,2	91,0	85,5	77,7	3,1	7,0	10,0	6,6	90	82		*N.*	w.	N. o.	do	do	cirri. haze.
30	,925	,008	,921	,973	74,2	81,0	88,8	83,7	77,1	4,2	7,0	11,5	5,1	88	77		*N. E.*	*w.*	N. o.	cir. str.	do	haze.
31	,962	,026	,927	,976	74,2	81,3	90,	84,1	77,0	4,0	10,7	12,6	6,5	80	75		n. e.	*n.*	N.	clear.	clear.	clear.
Mean,	,790	,860	,751	,819	78,8	85,2	93,5	86,8	80,7	2,5	5,6	7,6	4,3	91	87	3,68		calms.			fine weather.	

On the 4th at 7 h. 45 m. A. M. an earthquake was felt in Calcutta, and more severely at Monghyr, Patna, Tirhoot, the Rotas hills, Allahabad, &c.; on the 18th another shock was experienced at the same places more moderate and of shorter duration. On the 26th a third was felt in Nipal, and more moderately on the plains.